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THESIS

**IMPLEMENTING COMPSTAT PRINCIPLES INTO
CRITICAL INFRASTRUCTURE PROTECTION AND
IMPROVEMENT**

by

Mark C. Molinari

December 2016

Thesis Advisor:
Co-Advisor:

Erik Dahl
Patrick Miller

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**IMPLEMENTING COMPSTAT PRINCIPLES INTO CRITICAL
INFRASTRUCTURE PROTECTION AND IMPROVEMENT**

Mark C. Molinari
Captain, New York City Police Department
B.S., St. John's University, 1995

Submitted in partial fulfillment of the
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**NAVAL POSTGRADUATE SCHOOL
December 2016**

Approved by: Erik Dahl
Thesis Advisor

Patrick Miller
Co-Advisor

Erik Dahl
Associate Chair of Instruction
Department of National Security Affairs

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ABSTRACT

Roads and bridges, as aspects of transportation that are at the center of critical infrastructure (CI), are central to evacuation and to emergency response. New York City CI needs an accountability and communication model to ensure future progress, focusing on maintenance and prioritized improvement. This thesis focuses on how a performance measurement system, such as the New York City Police Department's (NYPD) CompStat model, will improve and protect the critical infrastructure of New York City's roads and bridges. The author uses over 20 years of NYPD managerial experience to demonstrate the successes of the NYPD's CompStat program through its 22-year history and how those successes can be translated to improvement in accountability and communications in road and bridge construction and reconstruction. This thesis investigates CI issues, and multiple sample events demonstrate how using the CompStat model would have resulted in a different outcome. I make the recommendation to create a New York City Mayor's Office of Infrastructure using New York City Emergency Management's Emergency Support Functions (ESF) as a method of grouping agencies and private companies together to engage in pre-event non-emergency multi-agency conversations.

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TABLE OF CONTENTS

I.	INTRODUCTION.....	1
A.	RESEARCH QUESTION	1
B.	PROBLEM STATEMENT	1
C.	HYPOTHESIS.....	8
D.	RESEARCH DESIGN	11
II.	LITERATURE REVIEW	13
A.	BACKGROUND ON CI POLICY AND PROGRESS	13
1.	Government Directives Regarding CI	14
2.	Evaluations of Government CI Efforts	16
B.	COMPSTAT.....	19
C.	HOW DO WE FIX CI?	22
III.	CRITICAL INFRASTRUCTURE IN NYS AND NYC	25
A.	INTRODUCTION.....	25
B.	NEW YORK STATE.....	30
C.	NEW YORK CITY	33
D.	CONCLUSION	46
IV.	SAMPLE EVENTS.....	49
A.	ARTHUR KILL ROAD WIDENING	49
B.	BAY TERRACE, STATEN ISLAND, WATER RUNOFF.....	53
C.	EASTERN PARKWAY.....	57
D.	SUPERSTORM SANDY BUYOUT AND REBUILDING	60
E.	GATEWAY NATIONAL PARK.....	64
F.	HYLAN BOULEVARD—STATEN ISLAND EXPRESSWAY DETERIORATION	65
G.	MAJOR ACCIDENT ON VICTORY BOULEVARD	68
H.	CONCLUSION	71
V.	COMPSTAT.....	73
A.	OVERVIEW	73
B.	FOUR PRINCIPLES OF COMPSTAT	76
1.	Accurate and Timely Intelligence.....	76
2.	Effective Tactics	77
3.	Rapid Deployment	78
4.	Relentless Follow-up and Assessment	79

C.	MEETING	79
D.	COSTS, TECHNOLOGY, AND STAFFING	84
E.	OTHER USES OF COMPSTAT.....	85
F.	PERFORMANCESTAT MODELS	86
G.	CRITIQUES OF COMPSTAT MODELS.....	89
H.	CONCLUSION	93
IV.	ANALYSIS AND RECOMMENDATIONS.....	95
A.	INCREASED ACCOUNTABILITY FOR NYC CI	95
B.	INCREASED COMMUNICATION FOR NYC CI.....	99
C.	PRINCIPLES APPLIED TO NYC CI.....	102
1.	Accurate and Timely Intelligence.....	103
2.	Effective Tactics	103
3.	Rapid Deployment	104
4.	Relentless Follow-up	104
5.	Limitations.....	105
6.	Summary.....	105
VII.	CONCLUSION	109
	LIST OF REFERENCES	113
	INITIAL DISTRIBUTION LIST	125

LIST OF FIGURES

Figure 1.	I-35 Bridge Collapse	2
Figure 2.	Skagit River Bridge Collapse.....	3
Figure 3.	NYC Roadway	6
Figure 4.	Car Ownership Rates in NYC.....	35
Figure 5.	Cars on Metropolitan Transit Authority Bridges and Tunnels, 2011	36
Figure 6.	Resurfacing Gap, NYC Department of Transportation	39
Figure 7.	Pavement Life Cycle, Conditions, and Costs.....	40
Figure 8.	Travel Modes, Pre- and Post-Hurricane Sandy.....	42
Figure 9.	Roads with Most Vehicular Damage Claims.....	44
Figure 10.	Aerial View of Brookfield Park.....	50
Figure 11.	Aerial View of the Proposed Widening of Arthur Kill Road	52
Figure 12.	Street-Level View of Approved Widening	52
Figure 13.	Aerial Image of Bay Terrace Section of Staten Island	54
Figure 14.	Department of Design and Construction Capital Projects	56
Figure 15.	Department of Design and Construction Capital Projects	56
Figure 16.	New Installation of Storm Drain on the Corner of Twombly Avenue and Hopkins Avenue.....	57
Figure 17.	Pedestrian Island—Eastern Parkway	58
Figure 18.	Eastern Parkway Pedestrian Island Removal.....	59
Figure 19.	Street Map of Ocean Breeze, Staten Island	61
Figure 20.	Satellite Map of Ocean Breeze, Staten Island.....	61
Figure 21.	Map of Flood Zone, Ocean Breeze, Staten Island	62
Figure 22.	Department of Transportation Protected Streets Listing	63

Figure 23.	Gateway National Park Entrance	65
Figure 24.	Broken Concrete and Exposed Construction Rebar.....	67
Figure 25.	View of Northbound Hylan Boulevard Overpass	67
Figure 26.	Victory Boulevard Accident	69
Figure 27.	Victory Boulevard Accident	70
Figure 28.	Spiral of Decline	74
Figure 29.	NYPD Hierarchy.....	76
Figure 30.	CompStat Dais Overview	82
Figure 31.	CompStat Dais	83
Figure 32.	CompStat Podium	83
Figure 33.	Overlapping Mission Statements	96
Figure 34.	Hierarchy of CompStat Model and the Mayor's Office of Infrastructure Model	101

LIST OF TABLES

Table 1.	American Critical Infrastructure Ratings.....	5
Table 2.	Conceptual Model of an Integrated Infrastructure Management System.....	27
Table 3.	NYS Division of Homeland Security and Emergency Services Homeland Security Strategy 2014–2016, Goal 2	31
Table 4.	Road Conditions in Urban Cities in New York State	32
Table 5.	NYS Congestion Costs and Hours Lost.....	33
Table 6.	Carless Households	34
Table 7.	NYC Roads in Poor/Fair Condition.....	38
Table 8.	Commute Times, Pre- and Post-Hurricane Sandy	41

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LIST OF ACRONYMS AND ABBREVIATIONS

ASCE	American Society of Civil Engineers
CI	Critical Infrastructure
CIKR	Critical Infrastructure Key Resources
CPR	Citywide Performance Reporting
CRS	Congressional Research Service
DCO	Deputy Commissioner of Operations
DDC	Department of Design and Construction
DHSES	Division of Homeland Security and Emergency Services
DHS	Department of Homeland Security
DMI	Deputy Mayor of Infrastructure
EM	Emergency Management
ESF	Emergency Support Functions
FBI	Federal Bureau of Investigations
GAO	Governmental Accountability Office
MTA	Metropolitan Transit Authority
NPPD	National Protection and Programs Directorate
NPS	National Park Service
NYC	New York City
NYC CI	New York City Critical Infrastructure
NYC DoITT	New York City Department of Information Technology and Communications
NYPD	New York Police Department
NYSDOT	New York State Department of Transportation
QHSR	<i>Quadrennial Homeland Security Review</i>
PIP	Parks Inspection Program
SIRT	Staten Island Rapid Transit

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EXECUTIVE SUMMARY

Critical infrastructure (CI) comprises the assets and networks that assist in energy, health, defense, transportation, and other areas to promote an interconnected network of utilities and services. These assets must be monitored and improved in a prioritized manner to ensure proper working order and appropriate use of tax revenue designated to maintain those assets. This thesis explores implementation of a proven accountability system into the discipline of critical infrastructure to ensure communication, collaboration, and prioritization.

The CI discussed in this report is more than the ratings of potholes, roadway conditions, and bridges. CI conditions relate directly to Homeland Security concerns via evacuations during terror attacks or natural disasters as well as emergency response to those attacks and disasters or routine police, fire, and medical emergencies. The simple truth is that poor roadway conditions and construction projects slow down emergency vehicles during routine responses; a major catastrophe would result in substantially increased response times and, potentially, more lives lost.

The United States has a major problem with failing CI. This thesis examines a potential solution involving both real fixes in New York City (NYC) and also a planned system of accountability and communication that will enable that solution to become reality, possibly serving as a model for other U.S. cities. CI will continue to disintegrate without significant investment, and a proper system will ensure those investments go to best use in best practices. This thesis describes the federal system for CI beginning with federal orders and continuing through government critiques by the Congressional Research Service; the Government Accountability Office, and RAND—a nonprofit think-tank. However, when looking for specific research regarding municipal CI in New York City, the government review and oversight literature becomes nearly nonexistent. Any critiques found come from think-tank organizations and politicians in state and city government, rather than federal legislators or policy analysts. This thesis explores the gap between current system status and future improvements, and how to improve

functionality and accountability of agencies performing repairs and improvements of Critical Infrastructure Key Resources (CIKR).

This thesis contains sample events taken from local media sources, elected officials' reports, and personal observation, all of which demonstrate the severe effects of lack of communication between city agencies, including poor repairs, wasted taxpayer money, and delays in substantial genuine improvement to critical infrastructure. The goal of listing these sample events is to identify the need for pre-event, pre-construction communication to determine a correct course of action and ensuring this communication assists in developing and testing any post-event plans necessary in cases of evacuation and emergency response.

The transportation booms of the New Deal in 1933 and the interstate highway system in the 1950s have deteriorated to an unsafe condition infrastructure. What would a new New Deal investment look like for NYC CI, and how can accountability ensure improvement without waste?

An accountability system is needed to ensure agencies performing improvement and repair work to CIKR are working collaboratively and in a prioritized manner to provide protection and practical improvements. With so many different agencies, difficulties arise in accountability methods and are further complicated by necessary cooperation between different partners.

A system to promote communication and cooperation would address the prioritization of CI repairs and improvements. Homeland Security depends on CI to move people, products, and emergency equipment. Without proper functionality, a limit to improvements in CI will continue, due to the lack of government oversight, inadequate evacuation plans, lack of collaboration between city agencies and private entities, and shifting populations. The system of accountability recommended in this thesis requires private companies to be held accountable for inadequate work and communication to be established between city agencies and private companies.

CompStat is a crime reduction strategy employed by the New York City Police Department (NYPD) since 1994 that has significantly reduced crime in NYC while

encouraging communication-enhancing accountability. With more than two decades of experience in the NYPD, 16 as a supervisor, and more than 13 years attending and presenting at CompStat, the author examines whether the NYPD CompStat model or a similar model would greatly enable the rebuilding and re-envisioning of CI.

The Mayor's Office of Operations is tasked with rating city agencies and publishing their findings. It is overburdened and unable to monitor CI improvements adequately by fostering pre-event frequent periodic communication. This thesis recommends that the mayor's office prioritize CI by creating the NYC Mayor's Office of Infrastructure, and that the Office of Infrastructure implement a CompStat model to ensure CI fixes, by building on the existing Office of Operations Infrastructure theme, using NYC's Emergency Management Emergency Support Functions to group agencies. Adapting the NYPD's model of CompStat to CI improvement and protection will create a system of communication, accountability, and interagency collaboration. The application of CompStat principles and how they can be applied to CI protection and improvement is vital to this thesis topic.

The recommendations in this thesis are simple: New York City government must make agencies more interwoven in their responsibilities. The examples relate to city agencies entrusted with CI. The systems proposed should begin with those and expand to all disciplines. Currently, agencies track efforts on an individual, agency-based, silo-driven system. The proposed system for the NYC Deputy Mayor of Infrastructure and the CompStat Unit recommended within accomplishes three missions at once: increase accountability, improve communication, and promote inter-agency collaboration.

By bringing together principles from three city agencies—the Mayor's Office of Operations Infrastructure theme, NYC Emergency Management's Emergency Support Functions, and the NYPD's CompStat model of accountability, the new Mayor's Office of Infrastructure can promote and monitor communication and collaboration between agencies and private companies.

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My parents, Michael and Victoria Molinari, and my mother-in-law, Michele MacDonald, have sacrificed so much for my career well before this amazing educational opportunity. Thank you.

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I. INTRODUCTION

The United States has a major problem with failing critical infrastructure (CI). This thesis examines a potential solution involving both real fixes in New York City (NYC) and also a planned system of accountability and communication that will enable that solution to become reality, possibly serving as a model for other U.S. cities. With more than two decades of experience in the New York City Police Department (NYPD), 16 as a supervisor, and more than 13 years attending and presenting at CompStat (a NYPD program stressing accountability and communication), the author examines whether the current CompStat or a similar model would greatly enable the rebuilding and re-envisioning of CI.

CI is more than the ratings of potholes, roadway conditions, and bridges. CI conditions relate directly to Homeland Security concerns via evacuations during terror attacks or natural disasters as well as emergency response to those attacks, disasters, or routine police, fire, and medical emergencies. What would a new New Deal investment look like for NYC CI, and how can accountability ensure improvement without waste?

A. RESEARCH QUESTION

How well would a performance measurement system, such as the NYPD's CompStat model, improve and protect CI, specifically NYC's 6,145 miles of roads, of which 43 percent are deficient¹ and over 2,000 bridges, of which 20 percent are deficient?²

B. PROBLEM STATEMENT

The Department of Homeland Security (DHS) defines CI as "assets, systems, and networks, whether physical or virtual, so vital to the United States that their incapacitation or destruction would have a debilitating effect on security, national economic security, national public health or safety, or any combination thereof," as well

¹ "Highway Mileage Report 2014," New York State Department of Transportation, accessed October 8, 2016, <https://www.dot.ny.gov/highway-data-services>.

² "Bridges," New York City Department of Transportation, accessed October 8, 2016, <http://www.nyc.gov/html/dot/html/infrastructure/bridges.shtml>.

as the “essential services that underpin American society and serve as the backbone of our nation’s economy, security, and health.”³

Major CI failures, such as the I-35 Bridge collapse in Minnesota in 2007, shown in Figure 1, which killed 13 people and injured 145,⁴ demonstrate the dangers of continuing to neglect bridges and roadways and therefore the necessity to improve CI. The I-35 Bridge was built as part of the U.S. highway system boom that occurred in the 1960s. Another failing CI example is the Skagit River Bridge in Mount Vernon, Washington, which collapsed in 2013 after a truck struck a section of the bridge, as shown in Figure 2.⁵ The I-35 and Skagit collapses represent the possible fate of 70,000+ deficient bridges in the United States,⁶ many of which date to the 1930s.

Figure 1. I-35 Bridge Collapse⁷



Photo credit: Kevin Rofidal, United States Coast Guard

³ “What Is Critical Infrastructure?” Department of Homeland Security, accessed December 28, 2015, <http://www.dhs.gov/what-critical-infrastructure>.

⁴ S. Hao, “I-35W Bridge Collapse,” *Journal of Bridge Engineering* 15, no. 5 (2009): 608.

⁵ Jeffrey L. Horton, “Surviving an Interstate Bridge Collapse,” *Public Roads* 78, no. 3 (2014). <https://www.fhwa.dot.gov/publications/publicroads/14novdec/05.cfm>.

⁶ “Falling Apart: America’s Neglected Infrastructure.” CBS News. Accessed April 5, 2016. <http://www.cbsnews.com/news/falling-apart-america-neglected-infrastructure/>.

⁷ Source: “I-35 Bridge Collapse,” Wikipedia, retrieved September 28, 2016, https://upload.wikimedia.org/wikipedia/commons/thumb/7/77/Image-I35W_Collapse_-_Day_4_-_Operations_%26_Scene_%2895%29_edit.jpg/220px-Image-I35W_Collapse_-_Day_4_-_Operations_%26_Scene_%2895%29_edit.jpg.

Figure 2. Skagit River Bridge Collapse⁸



Photo credit: Sarah Aarthun

These collapses are indicative of outdated physical structures as well as a lack of systems to fix those structures. There is an immediate need to monitor the unattended deterioration and lack of accountability and prioritization in the CI system. The United States needs direct investment in CI and in the human communication and accountability training that will enable real and lasting improvements.

The need for emergency response to an incident, regardless of its size, is less frequently considered a connection between Homeland Security and CI, but it is nonetheless crucial. Examples of the relationship between CI and Homeland Security include an ambulance getting to a sick or injured person, a fire truck going to a residential fire, a police car responding to a victim, or a mass mobilization of all of these resources combined in cases of large-scale attacks or natural disasters. The simple truth is that poor roadway conditions and construction projects slow down emergency vehicles during routine responses; a major catastrophe would result in substantially increased response times and, potentially, more lives lost.

Roads and bridges all over the United States are outdated, impaired, and documented as inferior by civil engineers, research groups, and transportation agencies, but improvement models have not been implemented. The U.S. transportation

⁸ Source: "Washington Bridge Collapses," CNN, May 26, 2013, <http://www.cnn.com/2013/05/24/us/gallery/skagit-river-bridge/index.html>.

infrastructure boom had two phases. The first was part of President Roosevelt's New Deal (1933) to help the country recover from the Great Depression. The second was in the 1950s and 1960s, when the establishment of the nation's interstate highway system connected the country.⁹ The roads and bridges constructed were not intended for use as long as they have been in service; 84 years since the New Deal and 66 years from the highway system expansion, respectively. Traffic volume, as well as vehicular weights, have increased exponentially. Current estimates by the Congressional Budget Office state that \$20 billion a year is needed to maintain CI's current inadequate levels or \$80 billion a year to show positive advances.¹⁰

The ratings in Table 1 indicate major CI failures, ultimately resulting in damage and loss of life. The literature review in Chapter II includes federal CI protection plans generated by the DHS and analyses of those plans and processes by organizations such as the Congressional Research Service (CRS), Governmental Accountability Office (GAO), and RAND Corporation. This literature documents the lack of follow-up and accountability in CI protection and improvement. American Society of Civil Engineer (ASCE) reports, such as those used to generate the information included in Table 1, document the dangerously poor state of roads and bridges both nationally and locally.

⁹ "America's Crumbling Infrastructure: Bridging the Gap," *Business Insider*, June 29, 2014, accessed May 22, 2016. <http://www.businessinsider.com/americas-crumbling-infrastructure-bridging-the-gap-2014-6>

¹⁰ "America's Transport Infrastructure: Life in the Slow Lane," *The Economist*, April 28, 2011, accessed May 22, 2016. <http://www.economist.com/node/18620944>.

Table 1. American Critical Infrastructure Ratings

Critical Infrastructure Field	Nation ¹¹	New York City, NY		Philadelphia, PA ¹²		Washington, DC ¹³	Los Angeles, CA ¹⁴
	2009	2013 ¹⁵	2015 ¹⁶	2010	2014	2016	2012
Energy	D+	D+			C	C	
Transit	D	D	C	D-	D	D	C
Ports		C			C+		B
Aviation	D	D	C				
Levees	D-	D-			C-	D-	
Dams	D	D	C-	C-	C-		B-
Schools	D	D		B-	C-	C-	
Roads	D-	D	D-	D-	D-	D+	C-
Inland Waterways	D-	D-		D+	D+		
Wastewater	D-	D	D	D+	D-	C+	B+
Hazardous Waste	D	D			B-		
Public Recreation	C-	C-	B-	B-	B-	C+	
Rail	C-	C+		B	B	B-	
Bridges	C	C+	D+	C	D+	B-	C
Solid Waste	C+	B-	B-	B-	C+	C+	B+
Drinking Water	D-	D	C	D+	D	C+	C
Storm Water				D-	D+		B+
TOTAL	D	D+	C-				

¹¹ “Report Card for America’s Infrastructure” American Society of Civil Engineers, 2009, accessed December 28, 2015, http://www.infrastructurereportcard.org/2009/sites/default/files/RC2009_full_report.pdf.

¹² “Report Card for Pennsylvania’s Infrastructure,” American Society of Civil Engineers, 2013, accessed December 28, 2015, <http://www.pareportcard.org/>.

¹³ “Report Card for Washington DC’s Infrastructure,” American Society of Civil Engineers, 2016, accessed February 15, 2016, <http://www.infrastructurereportcard.org/wp-content/uploads/2016/01/ASCE-DC-Report-Card-2016-Report.pdf>

¹⁴ “Report Card for Los Angeles County Infrastructure,” American Society of Civil Engineers, 2012, accessed December 28, 2015, http://s247942916.onlinehome.us/pdf/2012-ASCE-Report%20Card-Revised-10-2-2012-REVISED_FINAL_FOR%20THE%20WEBSITE.pdf

¹⁵ “Report Card for New York’s Infrastructure” American Society of Civil Engineers, 2013, accessed December 28, 2015, <http://www.infrastructurereportcard.org/asce-news/new-york-infrastructure-receives-report-card/>.

¹⁶ “Report Card for New York’s Infrastructure” American Society of Civil Engineers, 2015, accessed December 28, 2015, http://www.infrastructurereportcard.org/new_york/newyork/.

Table 1, based on the American Society of Civil Engineers' "Report Card for America's Infrastructure" as well as the ASCE's regional reports, shows the only reviews of CI that document nationwide conditions and demonstrate the current realities of U.S. CI. It shows the nation's current CI rating by an independent agency, and can be used as a guideline for improvements. The low grades represent the need for improvement. The table also documents that New York City's roads rate lower or worse than its bridges.¹⁷ These examples of CI failure and listed deficiencies are indicators of future issues that need an immediate solution. Report cards assess the situation, but the outcome must be to prioritize solutions.

Figure 3. NYC Roadway¹⁸



Photo credit Chad Rachman

Poor roadways, created by inadequate upkeep, cost taxpayers in both tax dollars and private money spent on auto repairs. Odometer.com's article "20 Cities with the WORST Roads," rates New York City's roads as 6th of 20 of the worst roads in the

¹⁷ "Report Card for New York's Infrastructure," American Society of Civil Engineers, 2013, accessed December 28, 2015, http://www.infrastructurereportcard.org/wpcontent/uploads/2015/09/NY_ReportCard_FullReport_9.29.15_FINAL.pdf.

¹⁸ "NYC Is Pothole City," *New York Post*, March 19, 2015, <http://nypost.com/2015/03/19/new-york-city-is-one-big-pothole/>.

United States, costing an average of \$2,300 per year per motorist for auto repairs of which 74 percent of the roads are in either mediocre or poor condition.¹⁹ Lucius Riccio, a researcher with Columbia University's Data Science Institute, states that "chronic underfunding of road repairs for nearly 20 years left city streets in poor shape and thus, prone to potholes,"²⁰ and "80 percent of potholes are due to inadequate resurfacing,"²¹ further demonstrating that a solution to CI issues of accountability and pre-event communication will avoid these inadequacies.

The homeland security enterprise must assist in the strategic foresight needed to improve upon critical infrastructure key resources (CIKR) in a prioritized, successful, and cost-effective manner that ensures accountability. The effect of CI failures on Homeland Security is multi-faceted. Homeland Security serves to protect CIKR, such as bridges, roadways, transportation centers (airports, train stations, and bus stations), and also cyber assets, where vital information is often stored and transferred. Part of that CI protection responsibility necessitates an attack deterrence framework.

CI will continue to disintegrate without significant investment, and a proper system will ensure those investments go to best use in best practices. CI is increasingly in danger of destruction by natural or accidental causes or a terrorist attack.²² Components of CI are also not self-contained; they overlap and impact one another and affect different services. Santos, Haimes, and Lian are CI researchers who write, "in order to ensure the stability, sustainability, and operability of our critical economic and infrastructure sectors, it is imperative to understand their inherent physical and economic linkages, in addition to their cyber interdependencies."²³ These interdependencies can create

¹⁹ "20 Cities with the Worst roads," Odometer, retrieved September 29, 2016, <http://www.odometer.com/lifestyle/4672/20-cities-with-the-worst-roads/#page=6>.

²⁰ Lucius Riccio, "Applying Data Science to the War on Potholes," Columbia University Data Science Institute, March 15, 2016, <http://datascience.columbia.edu/applying-data-science-war-potholes>.

²¹ Ibid.

²² According to the 2013 American Society of Civil Engineers *Report Card for America's Infrastructure*, the current rating is a D+ with an estimated \$3.6 billion dollars needed to be invested by the year 2020.

²³ Joost R. Santos, Yacov Y. Haimes and Chenyang Lian, "A Framework for Linking Cybersecurity Metrics to the Modeling of Macroeconomic Interdependencies," *Risk Analysis* 27, no. 5 (2007): 1283.

obstacles to improvement, but the system proposed in this thesis uses CI's interconnected nature to group infrastructure aspects into a forum promoting communication.

C. HYPOTHESIS

An accountability system is needed to ensure agencies performing improvement and repair work to CIKR are working collaboratively and in a prioritized manner to provide protection and practical improvements. With so many different agencies, difficulties arise in accountability methods and are further complicated by necessary cooperation between different partners. CIKR is currently owned and managed by a combination of federal, state, and municipal entities as well as private corporations. Some difficulties are getting these partners to unite, agree, and work together due to stakeholders' diverse interests. Also, currently, the federal government has no regulatory authority over private industry. As such, there is no way to oversee these exchanges. The accountability system needs to be non-adversarial and to encourage free conversation,²⁴ and the system also cannot be punitive.²⁵

Applying an effective CI communication and accountability model similar to the NYPD's CompStat program would increase the performance of agencies and assist in emergency response and evacuation procedures. The NYPD's CompStat program, which revolutionized the way law enforcement agencies work and created safer cities across the country, is a crime reduction program that began in New York City in 1994. The model is twofold, with accountability being the focus and addressing quality-of-life crimes as a component. The theory is to address smaller crimes in an area before larger crimes occur. The correlation holds true in CI, where we could address minor concerns before they become larger. The Federal Bureau of Investigation (FBI) tracks crimes nationwide utilizing a Unified Crime Report classification guide, which ensures different jurisdictions are tracking the same types of crimes (index crimes) regardless of what a

²⁴ Robert D. Behn, "Designing PerformanceStat: Or What Are the Key Strategic Choices That a Jurisdiction or Agency Must Make When Adapting the Compstat/Citistat Class of Performance Strategies?" *Public Performance & Management Review* 32, no. 2 (2008): 218.

²⁵ James J. Willis, David Weisburd, and Stephen D. Mastrofski, *Compstat in Practice: An In-Depth Analysis of Three Cities* (Washington, DC: Police Foundation, 2003).

jurisdiction names that crime.²⁶ When created, CompStat used these index crimes to focus resources and prioritize the New York City Police Department's mission. Since its inception in the NYPD, CompStat produced a 77.4 percent decrease in index crimes, including an 85 percent reduction in homicides.²⁷ The original NYPD CompStat principles are accurate and timely intelligence, effective tactics, rapid deployment, and relentless follow-up and assessment.²⁸

The author uses his Compstat experience of witnessing the principles, procedures, and policies and compares that experience to academic articles regarding CompStat to posit potential CI applications, including the creation of the Mayor's Office of Infrastructure. The personal knowledge and expertise are coupled with available research to demonstrate the success of the NYPD's CompStat program, similar programs in other cities, and programs in other disciplines modeled after the NYPD.

This thesis recommends the use of a proven performance management style, CompStat, into a discipline that requires communication and accountability measurement for improvement. The author's experience forms the basis to apply the CompStat principles to CI protection and improvement as follows:

- Early collection of issues to be addressed
- Multi-agency collaboration
- Prioritized workload
- Post-event or post-improvement critiques

This thesis also explores the gap between what has been done and what needs to be done to fix New York City's CI. Topics discussed cover how to improve the functionality, communication, and accountability of agencies performing repairs and improvements of CI. The research draws a conclusion between what RAND, the GAO,

²⁶ "Unified Crime Report." Federal Bureau of Investigation. Retrieved May 8, 2016.
<https://www.fbi.gov/about-us/cjis/ucr/ucr>.

²⁷ "Compstat 2.0." New York City Police Department. Retrieved May 7, 2016.
<https://Compstat.nypdonline.org/>.

²⁸ Jeff Godown. "The Compstat Process: Four Principles for Managing Crime Reduction." *The Police Chief* 76, no. 8 (2009): 36–38.

and the CRS state the federal government needs to do to correct CI nationally and applies that conclusion to the same CI areas in NYC. The anticipated outcome is the effect that applying CompStat principles will have in CI protection and improvement projects as well as a projection of how these principles will affect future projects.

The New York State Office of Emergency Management (NYS OEM), particularly the Office of Counter Terrorism, oversees the NYS system of CI protection and improvement but, contrary to the federal system, there are no outside entities analyzing the NYC system. This thesis' research shows inadequate oversight at the local NYC level.

The NYC Mayor's Office of Operations "monitors the performance of all City agencies, holding each agency accountable for providing high quality services and making data about the City's performance readily available to the public."²⁹ Their website uses numerous indicators to detail agencies' performance. The NYC Mayor's Office of Operations provides this information via the Citywide Performance Reporting (CPR) tool.³⁰ The CPR tool assigns similar aspects of all city agencies to eight citywide themes, including Public Safety, Legal Affairs, Education, and Infrastructure. The Infrastructure theme consists of reports on city agencies tasked with infrastructure but the Mayor's Office of Operations does not define collaboration, coordination, or accountability and it does not encourage participation of private companies. The word "theme" implies a lack of accountability and a change to the Office of Infrastructure promotes responsibility.

NYC Emergency Management (EM) "plans and prepares for emergencies, educates the public about preparedness, coordinates emergency response, and recovery, and collects and disseminates emergency information."³¹ City agencies and private companies working in the same disciplines are combined into EM's emergency support functions (ESF) model for post-event repairs and mitigation. This thesis recommends creating an office of the Deputy Mayor of Infrastructure (DMI), using EM's ESF model of combining city agencies

²⁹ "Mission," NYC Mayor's Office of Operations, retrieved October 15, 2016, <http://www1.nyc.gov/site/operations/about/about.page>

³⁰ "CPR: Agency Performance Reporting," New York City Mayor's Office, retrieved October 15, 2016, <http://www.nyc.gov/html/ops/cpr/html/home/home.shtml>.

³¹ "Overview," New York City Emergency Management, August 19, 2016, <http://www1.nyc.gov/site/em/about/overview.page>

and private companies to increase communication among all partners in NYC CI. Combining these models, in addition to implementing a CompStat unit within the Deputy Mayor of Infrastructure's office, fosters an accountability model to CI improvements. Moving Infrastructure from a sub-unit of the Mayor's Office of Operations into its own agency will show the dedication the mayor has to improving CI for all New Yorkers, as well as demanding accountability of the agencies responsible for NYC's CI.

D. RESEARCH DESIGN

To demonstrate the need for an accountability and communication model in CI, Chapter II provides a literature review, examining government documents and academic works on CI and its current state. Next, Chapter III reviews think-tank organizations and engineering groups' ratings of CI by detailing causation of road conditions and future investment needed. Then, Chapter IV lists seven sample events of CI issues and city agencies' lack of communication and accountability. These events are collected from seminars presented by local elected officials, local media sources, and personal observation. Chapter V presents a detailed overview of the NYPD's CompStat model and similar models, not only focusing on successes but also listing critiques and limitations. Then, Chapter VI analyzes the methodology of implementing the CompStat model into CI, including structure of the office designated to monitor agencies' progress. Lastly, Chapter VII concludes the thesis by stressing the benefits of conducting a CompStat system and the importance of communication, accountability, and monitored improvement in NYC CI by creating the Mayor's Office of Infrastructure.

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II. LITERATURE REVIEW

Chapter I reviewed failing critical infrastructure in the United States and hypothesized a solution for NYC. Although grades and rating systems indicate that most aspects of CI in NYC need work, this thesis focuses on NYC roads and bridges and improving them through the NYPD's CompStat model. Chapter II reviews literature regarding CI, beginning with government documents and critiques of those documents. Next, the chapter reviews literature on CompStat, including both negative and positive aspects, followed by literature on the current state of CI by think tank organizations.

A. BACKGROUND ON CI POLICY AND PROGRESS

Due to the lack of government plans and overwhelming number of critiques of road and bridge conditions in New York City, this thesis compares CI on a regional level to that on a national level. The thesis first examines the plans, policies, and goals issued by the federal government regarding critical infrastructure protection. Next we explore the critique of those policies and plans, then examine descriptions and criticisms of CompStat, and finally discuss the need of New York City roadways to be maintained and improved in a more efficient manner. Even though the government produces many reports regarding improvements to CI, and federal agencies tasked with reviewing these reports have chronicled the failures of agencies, little literature exists on how to fix CI.

Are there current accountability methods, measurement systems, or metrics in place to ensure productive, priority-based protection and improvement to CIKR? Research says not yet. Reviews by the GAO, RAND, and CRS all recommend implementation of a better form of metrics. These reports ask one question: How is DHS tracking improvements made in disaster preparedness? These reports address the lack of DHS (and sub-agencies) measuring successes, tracking improvements, and monitoring the results of their published goals. The system recommended in this thesis will create a communication model and an accountability aspect to ensure correct follow-up.

1. Government Directives Regarding CI

Government documents, such as plans, guidelines, goals, and after-action plans, have examined CI issues since at least the early 1990s, and have included the creation of Executive Orders and Presidential Policy Directives. When we think of homeland security, we may think of the post-9/11 world, but the orders, especially as they relate to CI, date further back.

In 1996, President Clinton issued orders to monitor, improve, share and analyze information regarding CI. Executive Order 13010, published by President Clinton on July 15, 1996, established the President's Commission on Critical Infrastructure Protection, tasked to recommend a national policy and strategy to protect CI from physical and cyber threats.³² This order is the first to mention partnerships between the public and private sectors. Presidential Decision Directive 63, issued by President Clinton in 1998, created information sharing and analysis centers to allow the government and critical infrastructure owners (city, state, and federal agencies and private companies that own CI components) to consult with each other.³³

President Bush issued Executive Orders to create DHS and to establish “establish readiness metrics to measure progress.”³⁴ These readiness metrics were never specified, and the federal government did not follow up to ensure the establishment of metrics. Executive Order 13228, issued in 2001, created the Office of Homeland Security.³⁵ Executive Order 13231 of 2001 includes the Congressional Approval of DHS.³⁶ The Homeland Security Act of 2002 established the Department of Homeland Security as an

³² William Jefferson Clinton, “Executive Order 13010—Critical Infrastructure Protection,” *Federal Register* 61, no. 138 (1996): 37347–37350.

³³ William Clinton, *Presidential Decision Directive 63* (Washington, DC: The White House, 1998).

³⁴ George W. Bush. “Homeland Security Presidential Directive (HSPD) 8. 17 December 2003.” *Critical Infrastructure Identification, Prioritization, and Protection*. Accessed March 11, 2016, <http://www.whitehouse.gov/news/releases/2003/12/20031217-7>. Html.

³⁵ George W. Bush, “Executive Order 13228: Establishing the Office of Homeland Security and the Homeland Security Council,” *Federal Register* 66, no. 196 (October 10, 2001): 51812–51817.

³⁶ George W. Bush, “Executive Order 13231: Critical Infrastructure Protection in the Information Age,” *Federal Register* 66, no. 202 (October 18, 2001): 53063–53071.

Executive Department with the mission of preventing terrorism within the United States.³⁷

President Bush also issued orders to bolster CI and to measure improvements. The Homeland Security Presidential Directive (HSPD)-7 signed on December 17, 2003, “requires federal departments and agencies to identify, prioritize, and protect” U.S. CI assets.³⁸ Homeland Security Presidential Directive (HSPD)-8, issued at the same time, developed the goal of organizing national efforts and investments to strengthen preparedness and to “establish readiness metrics to measure progress.”³⁹ Again, these readiness metrics were never specified, and the federal government did not follow up to ensure the establishment of metrics.

Methods of threat assessment were introduced in orders issued by President Obama in 2011. HSPD-8 created the National Preparedness Guidelines and the National Preparedness System.⁴⁰ This system identifies practices that would be used to generate the National Preparedness Goal and the National Preparedness Report, such as the Threat and Hazard Identification Risk Assessment (THIRA) and the 31 Core Capabilities that Federal Emergency Management Agency (FEMA) utilizes. On February 12, 2013, President Obama signed Presidential Policy Directive 21, which created the National Infrastructure Protection Plan.⁴¹

Implementing the Recommendations of the 9/11 Commission Act of 2007 requires the publication of the *Quadrennial Homeland Security Review* (QHSR) every four years.⁴² The first version, published in 2010, describes how events after 9/11 and the

³⁷ Homeland Security Act of 2002, Pub. L. No. 107–296, 116 Stat. 2135 (2002).

³⁸ George W. Bush, “Homeland Security Presidential Directive (HSPD-7): Critical Infrastructure Identification, Prioritization, and Protection,” *Weekly Compilation of Presidential Documents* 39, no. 51 (December 22, 2003): 1816–1822.

³⁹ Bush. “Homeland Security Presidential Directive (HSPD) 8. 17 December 2003.”

⁴⁰ “Homeland Security Policy Directive 8: National Preparedness,” White House, December 17, 2003. http://www.dhs.gov/files/publications/gc_1189788256647.shtm.

⁴¹ Barack Obama. *Presidential Policy Directive/PPD-21: Critical Infrastructure Security and Resilience* (Washington, DC: White House, 2013).

⁴² Implementing Recommendations of the 9/11 Commission Act of 2007, Pub. L. 110-53, 121 Stat. 266 (2007).

creation of DHS showed the need for links between homeland security and other functions, such as securing borders, managing immigration, and critical infrastructure. The *2014 Quadrennial Homeland Security Review* builds on the 2010 report as well as critiques of that report. The 2014 version states DHS will adopt strategic shifts and renew emphasis on strengthening the execution of DHS's mission through public-private partnerships.⁴³ Based on reviews by GAO, CRS, and RAND, the QHSR and HSPD-8 require that metrics be developed, yet never gave the format to be used to formulate or institute those metrics.

2. Evaluations of Government CI Efforts

Government monitoring groups, such as RAND, the CRS, and the GAO, also produce reports on CI. Most of these reports regard how DHS (and sub-agencies) have lacked measuring successes, tracking improvements, and monitoring results of their declared goals.

Even though the government produces reports regarding improvements made to CI and the federal agencies tasked with reviewing these documents issue reports on the failures of agencies, there is little literature on how to specifically fix that disconnect. DHS produces documents such as the *National Infrastructure Protection Plan* and the *National Preparedness Report* while the GAO and CRS indicate a lack of progress. The cycle of failures continues as GAO and CRS reports call for DHS to develop metrics, but they do not provide guidance or advice as to what kind of metrics to develop or how to implement those metrics. Twenty years later, specifics are more necessary than ever, and NYC has an opportunity to build on CompStat and lead the country.

Multiple reports issued by the GAO address a lack of initiative by DHS in advancement of CI monitoring. A 2011 GAO report documents failures by FEMA, including seven different previously discussed efforts and recommendations that had not

⁴³ Ibid.

been implemented.⁴⁴ The report states the following regarding measurable performance indicators:

Thus, identifying measurable performance indicators could help FEMA (1) track progress toward established goals, (2) provide policy makers with the information they need to make rational resource allocations, and (3) provide program managers with the data needed to effect continual improvements, measure progress, and to enforce accountability.⁴⁵

GAO issued reports documenting failures, but the recommendations were not followed and CI continues to deteriorate. This thesis describes a performance management and accountability model employing those indicators, allocations, data, and measured progress for positive efforts.

In 2013, GAO issued a report as a follow up to the 2009 report on deteriorating CI.⁴⁶ The newer report states: “in April 2009, we reported that establishing quantifiable metrics for capabilities was a prerequisite to developing assessment data that can be compared across all levels of government.”⁴⁷ A 2014 GAO report details the National Protection and Programs Directorate (NPPD) within DHS.⁴⁸ The NPPD is responsible for leading the coordinated effort and partnership between the sector-specific agencies and the private sector. In 2011, the Senate Committee on Appropriations directed that the NPPD report to the Committee within 60 days to outline efforts made in improvements, including implementing performance metrics.⁴⁹ The GAO failed to provide instruction in the development of and implementation of performance metrics. In August 2013, the DHS

⁴⁴ U.S. Government Accountability Office, *Measuring Disaster Preparedness: FEMA Has Made Limited Progress in Assessing National Capabilities* (GAO-11-260) (Washington, DC: U.S. Government Accountability Office, 2011), 2, <http://www.gao.gov/new.items/d11260t.pdf>.

⁴⁵ Ibid.

⁴⁶ U.S. Government Accountability Office, *National Preparedness: FEMA Has Made Progress, but Additional Steps Are Needed to Improve Grant Management and Assess Capabilities*. (GAO-13-637T) (Washington, DC: U.S. Government Accountability Office, 2013): 8, <http://www.gao.gov/products/GAO-13-637T>.

⁴⁷ Ibid.

⁴⁸ U.S. Government Accountability Office, *Critical Infrastructure: Assessment of the Department of Homeland Security's Report on the Results of Its Critical Infrastructure Partnership Streamlining Efforts* (GAO-14-100R) (Washington, DC: U.S. Government Accountability Office, 2014), <http://www.gao.gov/products/GAO-14-100R>.

⁴⁹ U.S. Government Accountability Office, *National Preparedness*, 8.

responded with a report that failed to address the points made by the Senate Committee. The reports written from 2009 until 2014, state that more must be done to define and implement measurement performance metrics. The latter reports indicate that those metrics were never developed, yet still do not recommend how to do so.

More recent releases by the GAO highlight the difficulties in the partnership program between sector-specific agencies and the private sector but also list the failures of private industry to cooperate.⁵⁰ Another 2014 report focuses on the difficulty in assessing CI risks due to the different assessment tools and methods used.⁵¹ A review by the GAO shows that DHS is unable to integrate vulnerability assessments due to different agencies using different tools to measure different aspects of CI. For example, a 2015 GAO report on electromagnetic threats covers a wide array of issues with the National Infrastructure Protection Plan's establishment of the sector-specific Agencies and the necessary partnership agreement.⁵² Recommendations state that "testing standards and measurable improvement metrics should be defined as early as possible and kept up to date."⁵³

This section documented a consistent lack in specifics over a period of more than two decades despite recurring recommendations of the need for metrics. The next section explores the recommendations of GAO and incorporates them into a NYC model of accountability and communication based on the CompStat principles, positing an adaption of CompStat as a means to generate specific fixes and metrics.

⁵⁰ U.S. Government Accountability Office, *Critical Infrastructure Protection: Observations on Key Factors in DHS's Implementation of its Partnership Approach* (GAO 14-464) (Washington, DC: U.S. Government Accountability Office, 2014), <http://www.gao.gov/products/GAO-14-464T>

⁵¹ U.S. Government Accountability Office, *Critical Infrastructure Protection: DHS Action Needed to Enhance Integration and Coordination of Vulnerability Assessment Efforts* (GAO 14-507) (Washington, DC: Government Accountability Office, 2014), <http://www.gao.gov/products/GAO-14-507>.

⁵² U.S. Government Accountability Office, *Critical Infrastructure Protection: Preliminary Observations on DHS Efforts to Address Electromagnetic Threats to the Electric Grid*. (GAO-15-692) (Washington, DC: U.S. Government Accountability Office, 2015), <http://www.gao.gov/products/GAO-15-692T>.

⁵³ Ibid.

B. COMPSTAT

There is a wealth of literature on CompStat starting with the launch of the program in New York City in 1994, and this literature can be expected to increase as more departments and disciplines attempt to incorporate CompStat-style tools into their respective agencies or fields. Most literature examines the development of CompStat and the distribution to other police agencies and then to other city agencies. A 1999 study revealed that a third of large departments had a “CompStat-like program” and an additional 26 percent planned to initiate one.⁵⁴

In researching performance metrics, we review the literature regarding general performance metrics and then, more specifically, metrics for the NYPD’s CompStat program. Performance management researchers credit the creation of CompStat to Police Commissioner William Bratton of the NYPD. Some literature states that the ideas started with Bratton’s policies in Boston in the late 1980s and early 1990s.⁵⁵ Academics studying CompStat and crime strategies, such as Behn, Willis, and Dabney, have studied the successes of CompStat and similar programs.

Researchers have attempted to identify progress that can be translated into performance management. While there is no generally accepted approach yet, computer advancement and data collection techniques will improve, but a methodology of how to quantify performance in CI improvements and prevention is needed. An article on the *Homeland Security Today* website states that “there is no comprehensive, strategic approach to identifying, prioritizing and implementing investments for disaster resilience, which increases the risk that the federal government and non-federal partners will experience lower returns on investments or lost opportunities to strengthen key Critical Infrastructure and lifelines.”⁵⁶ In 1998, transportation analyst A. C. Lemer stated that

⁵⁴ Willis, Weisburd, and Mastrofski, *Compstat in Practice: An In-Depth Analysis of Three Cities*.

⁵⁵ Dean Dabney, “Observations regarding Key Operational Realities in a Compstat Model of Policing,” *Justice Quarterly* 27, no. 1 (2010): 28.

⁵⁶ Anthony L. Kimery, “FEMA Outlines Decade of Progress after Hurricane Katrina, But Millions in Public Assistance Grants Misspent, IG Says,” *Homeland Security Today*, <http://www.hstoday.us/industry-news/general/single-article/fema-outlines-decade-of-progress-after-hurricane-katrina-but-millions-in-public-assistance-grants-misspent-ig-says/43d7822af3d3a03728600ee072aa5ac9.html>.

“innovative data-collection technologies and increased computational power will enable public works asset managers to gain better understanding of infrastructure performance and the public’s demand and expectations for its infrastructure.”⁵⁷ Taquechel and Lewis, who have written about how to deter attacks on CI, state that “there is a considerable repository of literature offering insights into how deterrence might be quantified, without ever explicitly stating how to quantify it for CI protection.”⁵⁸ Government directives and critiques all discuss the need for communication, accountability, and performance measurements, but do not specify a method of implementations.

Literature regarding performance management styles similar to the CompStat model include discussions of PerformanceStat, a term coined by Robert Behn to describe all of the CompStat-like programs nationwide, most of which incorporate either the location or the agency involved; Citistat in Baltimore; ParkStat in the NYC Parks Department; and LouieStat in St. Louis.⁵⁹ Behn points out that any PerformanceStat is strategy that should involve regular and frequent meetings, in which a “chief executive uses data to analyze past performance, follow up on previous decisions to improve performance, establish performance objectives and examine the effectiveness of performance strategies.”⁶⁰ Behn’s earlier literature on performance measurement details reasons to measure performance to achieve eight specific managerial purposes. Behn states that public agency leaders need to define the purpose of measurement, identify specific measures, and put the data obtained to practical use.⁶¹

⁵⁷ A. C. Lemer. “Progress toward Integrated Infrastructure-Assets-Management Systems: GIS and Beyond.” In *Innovations in Urban Infrastructure Seminar of the APWA International Public Works Congress*, (Washington, DC: American Public Works Association, 1998): 7.

⁵⁸ Eric F. Tauechel, and Ted G. Lewis, “How to Quantify Deterrence and Reduce Critical Infrastructure Risk,” *Homeland Security Affairs* 8, no. 12 (August, 2012), accessed March 29, 2016, <https://www.hsaj.org/articles/226>.

⁵⁹ Behn, “Designing PerformanceStat,” 206.

⁶⁰ Ibid., 215

⁶¹ Robert D. Behn, “Why Measure Performance? Different Purposes Require Different Measures,” *Public Administration Review* 63, no. 5 (2003): 588.

Positive reviews of the NYPD CompStat system continuously cite the awards won by the NYPD for changing crime fighting techniques.⁶² In 2001, George Keeling, a criminal justice researcher and author, called CompStat “perhaps the single most important organizational/administrative innovation in policing during the latter half of the twentieth century.”⁶³ The documented successes of the NYPD’s CompStat program depict a vast difference in crime reduction; adapting a CompStat model within the Mayor’s Office of Infrastructure is likely to create a medium increase in productivity, accountability, communication, and improvement to CI.

There are also critiques of CompStat. The most repeated idea references the tone and design of the meetings and quoted that CompStat can be “punitive” or “brutal.”⁶⁴ Due to this, there was an NYPD executive shift by the end of 1994.⁶⁵ Research yields allegations of supervisors downgrading crimes to make crime appear lower.⁶⁶ In 2009, Shelly Metzenbaum stated, “what is needed is a performance management approach that is outcome focused, measurement rich, and inquisitive but not punitive.”⁶⁷ In developing an accountability model for CI improvements, the positive and negative aspects of CompStat and similar programs must be addressed.

Behn and Willis give detailed examples of the process of these performance meetings, such as why they are needed, when to have, length, frequency, and organizational psychology that may exist. There must be a deficit that needs to be addressed, and pointing out flaws yields an analysis of what is happening⁶⁸ as well as

⁶² The NYPD won the 1996 “Innovations in American Government” award, sponsored by the Ford Foundation and Harvard’s Kennedy School of Government.

⁶³ George L. Keeling and William H. Sousa, *Do Police Matter? An Analysis of the Impact of New York City’s Police Reforms* (New York: CCI Center for Civic Innovation at the Manhattan Institute, 2001), 6.

⁶⁴ Willis, Weisburd, and Mastrofski, *Compstat in Practice: An In-Depth Analysis of Three Cities*, 21.

⁶⁵ Eli B. Silverman, “Mapping Change: How the New York City Police Department Reengineered itself to Drive Down Crime,” *Law Enforcement News*, December 15, 1996.

⁶⁶ Willis, Weisburd and Mastrofski, *Compstat in Practice*, 12.

⁶⁷ Shelley H. Metzenbaum, “Performance Management Recommendations for the New Administration” (2009). *Edward J. Collins Center for Public Management Publications*. Paper 11. 4. Retrieved on November 8, 2015, http://scholarworks.umb.edu/cpm_pubs/11.

⁶⁸ Willis, Weisburd and Mastrofski, *Compstat in Practice*, 7.

using this format as a “management tool to influence decisions.”⁶⁹ Behn also discusses the timing of the meetings, early morning as to not interfere with the regular work functions of those attending.⁷⁰ He then describes how the length and frequency of the meetings, as well as the room design, are crucial elements in a successful PerformanceStat set-up.⁷¹ One last point from multiple pieces of literature addresses the cultural psychology of professions and occupations. Will various offices adapt to this new thinking, tolerate the risk, and encourage new approaches?

Although the literature reviewed involves the need, history, and critiques of CompStat and programs like it, the application of CompStat principles and how they can be applied to CI protection and improvement is vital to this thesis topic. The first steps are to address the current mission, deficits, and technological framework. Once the mission is developed, the data to be analyzed must be shared with all members attending the meeting. The subject agency must spread an accurate portrayal of the stat processes, missions, and methodologies. Maintaining a professional, productive atmosphere is key to ensure a true method for improvement.⁷²

C. HOW DO WE FIX CI?

Many studies document the interconnectedness and interdependency of critical infrastructure but do not address how to get those connected parts to work more efficiently together. Agencies such as RAND, the GAO, and the CRS, concentrate on overall assessments of what the federal government is doing correctly or what needs to be improved. As such, there is little academic research on smaller-scale locations, such as what cities are doing correctly or incorrectly.

⁶⁹ Jamie Giles. “Do Municipal Stat Programs Improve Services and Reallocate Resources? Evidence from LouieStat,” (MPS/MPP Capstone Project, University of Kentucky, 2014), accessed March 29, 2016. http://uknowledge.uky.edu/mpampp_etds/4 , 1.

⁷⁰ Willis, Weisburd, and Mastrofski, *Compstat in Practice*, 7.

⁷¹ Ibid.

⁷² Paul E. O’Connell, *Using Performance Data for Accountability, the New York City Police Department’s Compstat Model of Police Management* (Arlington, VA: Pricewaterhouse Coopers Endowment for the Business of Government, 2001).

Experts in the field of CI research determine that increased budgets will be required to make necessary improvements, but money must be spent in a prioritized manner that is tested and evaluated, continuing future progress based on past improvements. In her 2013 work, Mayada Omer, a resilience product development expert at the University of Munich, references the need to make transportation systems more resilient, which “creates a need for developing metrics that measure the current resilience of the system and provides a benchmark for evaluating different strategies for improving resilience.”⁷³

Bruce Shaller is a CI researcher at New York University’s (NYU) Wagner School who presented at NYU’s Rudin Center. There, he references the 2010 New York State Capital Program for the New York State Department of Transportation (NYSDOT) for 2005 to 2010.⁷⁴ This program gives \$17.4 billion to NYSDOT’s Highway Capital projects, \$6 billion of which is for the 14 counties of downstate New York, including NYC.⁷⁵ Shaller’s research shows that a conservative plan to maintain highways during the reporting period, 2005–2010, would cost \$9 billion and a more aggressive plan to make improvements would be over \$13 billion.⁷⁶

Transportation analysts Winston and Mannering reported the need to involve private industry in improvements to public highway performance, including the requirement by law that private industries use the most modern technologies in roadway replacement and repair.⁷⁷ New York City’s PlaNYC, developed by Mayor Michael Bloomberg, references disasters such as Super Storm Sandy and the destruction caused by climate change. The report focuses mainly on public transit systems, as opposed to

⁷³ Mayada Omer, Ali Mostashari, and Roshanak Nilchiani. “Assessing Resilience in a Regional Road-based Transportation Network.” *International Journal of Industrial and Systems Engineering* 13, no. 4 (2013): 391.

⁷⁴ Bruce Schaller, *Choices at a Critical Junction: New York’s Mobility and Highway Infrastructure Needs for 2005-2010*. (New York: NYU Wagner Rudin Center for Transportation Policy & Management, 2005), 1.

⁷⁵ Ibid.

⁷⁶ Ibid.

⁷⁷ Clifford Winston and Fred Mannering, “Implementing Technology to Improve Public Highway Performance: A Leapfrog Technology from the Private Sector Is Going to be Necessary,” *Economics of Transportation* 3, no. 2 (2014): 158.

vehicular traffic on roads and bridges, with specific mention of roads and bridges considered a moderate risk due to weather-related incidents (precipitation or high heat) as opposed to marine traffic and subways being a high risk.⁷⁸ One cause of concern that the report fails to mention is, that once the transit and marine systems fail, already overburdened roads and bridges will become overwhelmed. Discussion in Comes' 2014 work citing Super Storm Sandy and the ensuing infrastructure shutdown involves a way to conceptualize interdependencies.⁷⁹

This thesis explores the gap between current system status and future improvements, and how to improve functionality and accountability of agencies performing repairs and improvements of CIKR. The hypothesis explored in this thesis is drawn between what RAND, the GAO, and the CRS state the federal government needs to correct and how we can solve a lack of initiative in the same areas in NYC. Chapter III addresses CI issues in NYC as reported by think-tank organizations and CI researcher.

⁷⁸ Michael Bloomberg, *A Stronger, More Resilient New York* (New York, PlaNYC Program, 2013).

⁷⁹ Tina Comes and Bartel Van de Walle, "Measuring Disaster Resilience: The Impact of Hurricane Sandy on Critical Infrastructure Systems." In *Proceedings of the 11th International Conference on Information Systems for Crisis Response and Management (ISCRAM2014)*, ed. Starr Roxanne Hiltz, Mark S. Pfaff, Linda Plotnick and Patrick C. Shih, 196. University Park, PA: Pennsylvania State University, 2014.)

III. CRITICAL INFRASTRUCTURE IN NYS AND NYC

The facilities of infrastructure are among civilization's most important assets, a storehouse of resources and wealth that each generation inherits, uses, and passes on to succeeding generations. Decisions influencing infrastructure development and use—asset management—undertaken and executed without fully recognizing the complexity, diversity, and social and technological evolution of the system almost inevitably squander economic, environmental, social, and cultural resources.

—A. C. Lemer⁸⁰

A. INTRODUCTION

Chapter II reviewed the literature regarding government plans and critiques of critical infrastructure, the successes of CompStat, and the current state of CI. Chapter III delves deeper into both NYC and NYS CI, detailing how usage and vehicle ownership affects road and bridge conditions. Chapter III also explores the effects of weather and emergency incidents on transportation and emergency response, highlighting the importance of improving CI in NYC.

Improving CI is more than just filling in potholes. This thesis describes the federal system for CI beginning with federal orders and continuing through government critiques by the CRS, the GAO, and RAND. However, as previously noted, when looking for specific research regarding municipal CI in New York City, the government review and oversight literature becomes nearly nonexistent. Any critiques found come from think-tank organizations and politicians in state and city government, rather than federal legislators or policy analysts. This chapter includes issues in New York City critical infrastructure as related by the United States Department of Homeland Security, the New York City Department of Transportation, New York State Division of Homeland Security plan, and private transportation firm ratings statewide. This thesis reviews current New York City roadway issues as reported by the Center for an Urban Future, the Rudin Center for Transportation, and the New York City government. The information cited

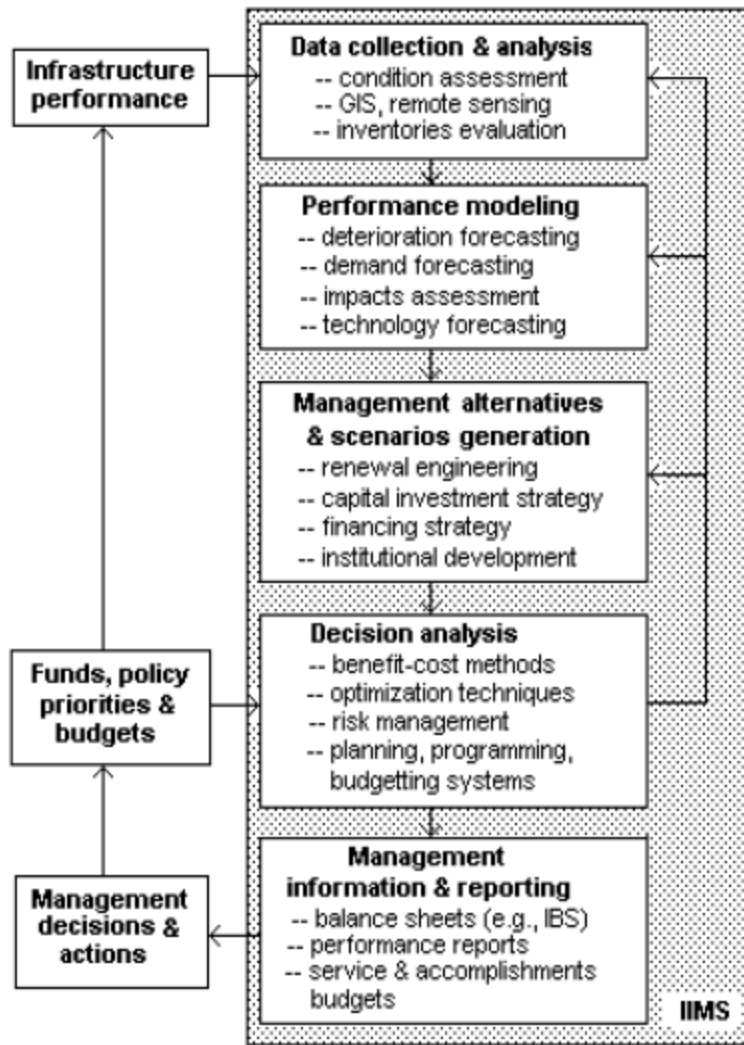
⁸⁰ Lemer. "Progress toward Integrated Infrastructure-Assets-Management Systems," 8.

from research organizations replaces the lack of governmental review and creates the accurate intelligence principle of the CompStat process. This thesis recommends a formation of the NYC Deputy Mayor of Infrastructure (DMI) and a CompStat unit therein to monitor CI agencies. The following research investigates whether roadway construction and repair can influence commuting, safety, finance, and evacuation, and increase communication and accountability in city agencies.

Work conducted collecting intelligence regarding CI is useless when there is no measurability, and those responsible are not held accountable. As A. C. Lemer, a transportation analyst who created the Integrated Infrastructure Management System (IIMS) states in his 1998 report, “the inefficiencies are widespread and easy to see: jammed traffic on roads designed to carry only a fraction of the current demand, newly resurfaced city streets ripped open to repair old subsurface pipes, news media expressing public outrage that traffic lanes must be closed for maintenance or that basements are flooded.”⁸¹ Lemer’s flowchart shows a process for infrastructure management, yet only small parts of each step involve accountability, as depicted in Table 2. To learn from the intelligence collection process, management must accurately compare intelligence collected versus previous reports or scenarios and advance from the information.

⁸¹ Ibid., 10

Table 2. Conceptual Model of an Integrated Infrastructure Management System⁸²



The chart in Table 2 depicts a cycle of intelligence collection similar to the CompStat process principles described in this thesis: data collection, tactics in the form of changing technology, and rapid deployment via repair work. The “Management decisions & actions box” is the only reference to actual learning described by relentless follow-up, but real accountability and learning is not addressed.

⁸² Source: Ibid, 11.

Multiple agencies and private corporations own the interconnected pieces of CI; this limits communication as public agencies and private corporations perform independently and without the follow-up stage that this thesis adapts from the NYPD CompStat model. Proprietary rights conflict with the need for transparency when fixing CI due to private companies owning CI and wanting to maintain industry-specific monopolies. Companies do not want to share trade information that gives their competitors an advantage.⁸³ In New York City, Mayor Bill DeBlasio initiated a working group to address this issue by having a neutral third party—possibly academic—responsible for the repository of such information.⁸⁴ This process allows for improvements without endangering corporate secrets. As explored in the introduction of this thesis, the Governmental Accountability Office cited failures in the Department of Homeland Security’s Sector-Specific Agency and Industry plans due to private industry withholding proprietary information to maintain industry superiority. Mayor DeBlasio’s plan would eliminate the secrecy and allow for more accurate information sharing. The working group is discussed further in this chapter regarding underground CI resources and private corporation’s proprietary rights.

Reports indicate trouble with emergency preparedness, yet we lack a follow-up plan. The system of accountability recommended in this thesis would incorporate a plan and critiques into a forum that discusses the issues and implements better ideas. DHS has released reports with overviews of urban CI, noting concerns with current evacuation plans in the major cities and the effects of population shifts on the nation’s CI system. After Hurricane Katrina in 2005, federal agencies reviewed evacuation plans for urban areas to assess the need for improvements. DHS’s *Nationwide Plan Review* and the Department of Transportation’s (DOT) *Catastrophic Hurricane Evacuation Plan Evaluation* cite that “some of the largest metropolitan areas in the United States—New

⁸³ U.S. Government Accountability Office, *Critical Infrastructure Protection: Observations on Key Factors in DHS’s Implementation of its Partnership Approach* (GAO 14-494) (Washington, DC: U.S. Government Accountability Office, 2014); Retrieved February 5, 2016, <http://www.gao.gov/products/GAO-14-494>

⁸⁴ “Infrastructure Report,” City of New York, New York City Underground Infrastructure Working Group, (June 2014), www1.nyc.gov/assets/home/downloads/pdf/press-releases/2014/infrastructure_report.pdf.

York City, Los Angeles, and Chicago—do not have adequate mass evacuation plans in place.”⁸⁵

A DHS case study demonstrated that fluctuations in population have adverse effects on infrastructure. An increase in population causes a greater need for transportation infrastructure. Expanding urban centers are growing faster than new infrastructure is built, improved, or retrofitted. In addition, a decrease in population causes shortfalls in funding. Households below the poverty line, retirees paying low taxes, and those who have outstanding tax liens create shortages to local economies.⁸⁶ Maintaining a stable population level while also increasing economic growth is best for CI needs.

The combination of population information, research into hours lost, fuel wasted, and emissions increased due to poor roads and improper construction schedules and depict a need for prioritized CI improvements. The American Highway Users Alliance is “a nonprofit advocacy organization serving as the united voice of the transportation community promoting safe, uncongested highways and enhanced freedom of mobility since 1932.”⁸⁷ Their report, *Unclogging America’s Highways 2015: Prescriptions for Healthier Highways*, identifies the 50 worst traffic bottlenecks in the United States. Number one is the Kennedy Expressway in Chicago. By way of comparison, this chokepoint extends 12 miles, costing drivers 16.9 million hours in time and wastes 6.3 million gallons of fuel annually.⁸⁸ These delays are not the result of a one-time event or a construction-related glitch. They are due to a poorly constructed interchange not built for its current usage amounts. By correcting this area, a reduction of 133 million pounds of

⁸⁵ Daniel Baldwin Hess and Julie C. Gotham, “Multi-Modal Mass Evacuation in Upstate New York: A Review of Disaster Plans,” *Journal of Homeland Security and Emergency Management* 4, no. 3 (2007).

⁸⁶ “Impact of Population Shifts on Critical Infrastructure,” Department of Homeland Security—Office of Cyber and Infrastructure Analysis, July 6, 2016. <https://www.dhs.gov/office-cyber-infrastructure-analysis>

⁸⁷ “About American Highway Users Alliance,” American Highway Users Alliance, accessed September 5, 2016, <http://www.highways.org/about/>.

⁸⁸ “Unclogging America’s Arteries 2015: Prescriptions for Healthier Highways,” American Highway Users Alliance, November 23, 2015, <http://www.highways.org/2015/11/unclogging-study2015/>.

carbon dioxide annually would be achieved.⁸⁹ New York City has nine of the 50 worst bottlenecks.⁹⁰

A system to promote communication and cooperation would address the prioritization of CI repairs and improvements. Homeland Security depends on CI to move people, products, and emergency equipment. Without proper functionality, a limit to improvements in CI will continue, due to the lack of government oversight, inadequate evacuation plans, lack of collaboration between city agencies and private entities, and shifting populations.

B. NEW YORK STATE

The New York State Office of Emergency Management monitors New York State Critical Infrastructure but does not provide the oversight for New York City CI that this thesis recommends; therefore, the city government must take on that responsibility itself. NYS OEM issues plans similar to those developed by the federal government, but those are not reviewed or critiqued by any agencies. The New York State Homeland Security Strategy for 2014–2016 identifies its second goal as protecting critical infrastructure and Key Resources.⁹¹ As evidenced in Table 3, increasing communication and accountability is not one of the objectives.

⁸⁹ Ibid.

⁹⁰ Ibid., 7.

⁹¹ “New York State Homeland Security Strategy 2014–2016,” New York State Division of Homeland Security and Emergency Services, accessed September 4, 2016, <http://www.dhses.ny.gov/media/documents/NYS-Homeland-Security-Strategy.pdf>.

Table 3. NYS Division of Homeland Security and Emergency Services
Homeland Security Strategy 2014–2016, Goal 2⁹²

Goal 2: Protect Critical Infrastructure and Key Resources <i>across New York State based on a systematic process of identifying and cataloguing infrastructure, conducting site visits and risk assessments, investing in target hardening projects, and providing additional protective and mitigation measures based on the current threat environment.</i>	
Objective Number	Objective
Objective 2.1	Conduct outreach to critical infrastructure owners and operators to support protection and emergency response efforts
Objective 2.2	Continue identifying and cataloging CIKR site information
Objective 2.3	Work with local, State, and Federal agencies and private entities to conduct critical infrastructure site visits
Objective 2.4	Assess and analyze threats, vulnerabilities, and consequences of critical locations through the completion of risk assessments
Objective 2.5	Implement physical security enhancements and target hardening activities to reduce identified risk at critical infrastructure locations, including emergency service and public safety facilities
Objective 2.6	Continue surge deployments of personnel at critical locations and mass gathering sites in accordance with the threat environment, such as Task Force Empire Shield and Transit Operational Response Canine Heavy (TORCH) weapons teams in the New York City Metropolitan Area
Objective 2.7	Leverage the use of technological platforms and database applications, such as Geospatial Information Systems (GIS) and risk-based modeling software, to support CIKR analysis
Objective 2.8	Promote safety efforts at schools and universities in New York State, in conjunction with local law enforcement agencies

Table 3, produced by the New York State Division of Homeland Security and Emergency Services (DHSES) as part of their *NYS Homeland Security Strategy 2014–2016*, depicts an excellent model for CI improvement, yet fails to discuss the issues

⁹² Source: Ibid.

recommended in this thesis: How can DHSES ensure participation, communication, and accountability?

TRIP, a private non-profit founded in 1971, promotes CI improvements to relieve traffic congestion. It is sponsored by those that create equipment or do the physical repairs associated with roadways.⁹³ The studies released by TRIP rate road conditions. Table 4 indicates the conditions of New York State roadways in urban areas, with New York City Metro rates being the worst in the state with 51 percent of the roads rated as poor and only 13 percent rated as good.⁹⁴

Table 4. Road Conditions in Urban Cities in New York State⁹⁵

Urban Area	Poor	Mediocre	Fair	Good
Albany	21%	30%	24%	25%
Binghamton	11%	36%	23%	29%
Buffalo	14%	33%	16%	37%
New York City Metro	51%	31%	5%	13%
Poughkeepsie-Newburgh	26%	30%	23%	22%
Rochester	11%	18%	31%	40%
Syracuse	30%	23%	17%	29%
Utica	7%	20%	27%	46%

Table 4 indicates that more than half of NYC metro roads are in poor condition and one-third in mediocre condition, leaving less than 20 percent in acceptable condition. NYC depends on CI for basic commuting, routine emergency response, and evacuation preparedness. This thesis develops an accountability measure to increase repairs of road conditions and follow-up on failures. When broken down along the same urban areas in

⁹³ “About TRIP,” TRIP, accessed September 5, 2016, <http://tripnet.org/about.php>.

⁹⁴ “New York’s Top Transportation Issues: Meeting the State’s Needs for Safe, Smooth, and Efficient Mobility,” TRIP—A National Transportation Research Group, accessed September 4, 2016, 3. http://www.tripnet.org/docs/NY_Top_Transportation_Issues_TRIP_Report_Jan_2016.pdf.

⁹⁵ Ibid., 6.

New York State, New York City experiences the most in congestion costs and commuting hours lost, as documented in Table 5.⁹⁶

Table 5. NYS Congestion Costs and Hours Lost⁹⁷

Urban Area	Congestion Cost	Hours Lost
Albany	\$991	42 hours
Binghamton	\$382	16 hours
Buffalo	\$918	40 hours
New York City Metro	\$1,739	74 hours
Poughkeepsie-Newburgh	\$867	37 hours
Rochester	\$889	39 hours
Syracuse	\$530	22 hours
Utica	\$433	19 hours

Table 5 presents the staggering dollar amount spent per year by the average motorist on congestion and work time lost due to the same congestion. There are many reasons for congestion, but this thesis addresses road conditions and road reconstruction that delay travel. Studies conducted by TRIP also denote past increases in population and how that will affect cities in the future. “New York’s population reached approximately 19.7 million residents in 2014, an 18 percent increase since 1990.”⁹⁸ Reports indicate growth in vehicular travel of approximately 3.3 percent over 2013, 2014, and 2015 as well as an anticipated 15 percent growth by 2030.⁹⁹

C. NEW YORK CITY

New York City CI differs from borough to borough, due to population density and roadway use; therefore, CI needs reflect those differences. There is a lack of research

⁹⁶ Ibid.

⁹⁷ Ibid.

⁹⁸ Ibid., 2.

⁹⁹ Ibid., 3.

regarding CI in NYC neighborhoods and how they are affected. Emergency response, evacuation, and daily travel are all affected by the deteriorating CI, which then creates repercussions for Homeland Security. The discrepancies in vehicle ownership in different boroughs, as well as the number of vehicles commuting through parts of the city, need to be tracked by the agencies responsible and the methodology of how to incorporate those discrepancies into CI protection and improvement must be collaborated. Compared with other metropolitan areas, New York City has the highest rate of households without access to private vehicles, as shown in Table 6.¹⁰⁰ This translates into the need for different methods of transportation to evacuate more people. Figure 4 outlines private vehicle ownership by boroughs and neighborhoods and is presented to display the disproportionate rate of vehicle ownership across New York City's boroughs. Parts of this thesis are dedicated specifically to Staten Island, New York, where vehicle ownership is the highest of any borough. Chapter IV discusses specific incidents with lack of communication affecting Staten Island.

Table 6. Carless Households¹⁰¹

City	Population	Households without Vehicles	Poverty Rate	Transit Fleet	
				Buses	Rail Cars
New York City, NY	7,735,264	56 %	21.2 %	4,539	6,127
Washington, DC	572,059	37 %	20.2 %	1,463	594
Baltimore, MD	651,154	36 %	22.9 %	931	268
Philadelphia, PA	1,517,550	36 %	22.9 %	1,365	934
Boston, MA	589,141	35 %	19.5 %	1,024	1,063
Chicago, IL	2,895,964	29 %	19.6 %	2,026	1,190
San Francisco, CA	776,733	29 %	11.3 %	544	845
New Orleans, LA	484,674	27 %	27.9 %	364	42
Miami, FL	362,563	27 %	28.5 %	957	136
Cleveland, OH	478,383	25 %	26.2 %	701	39

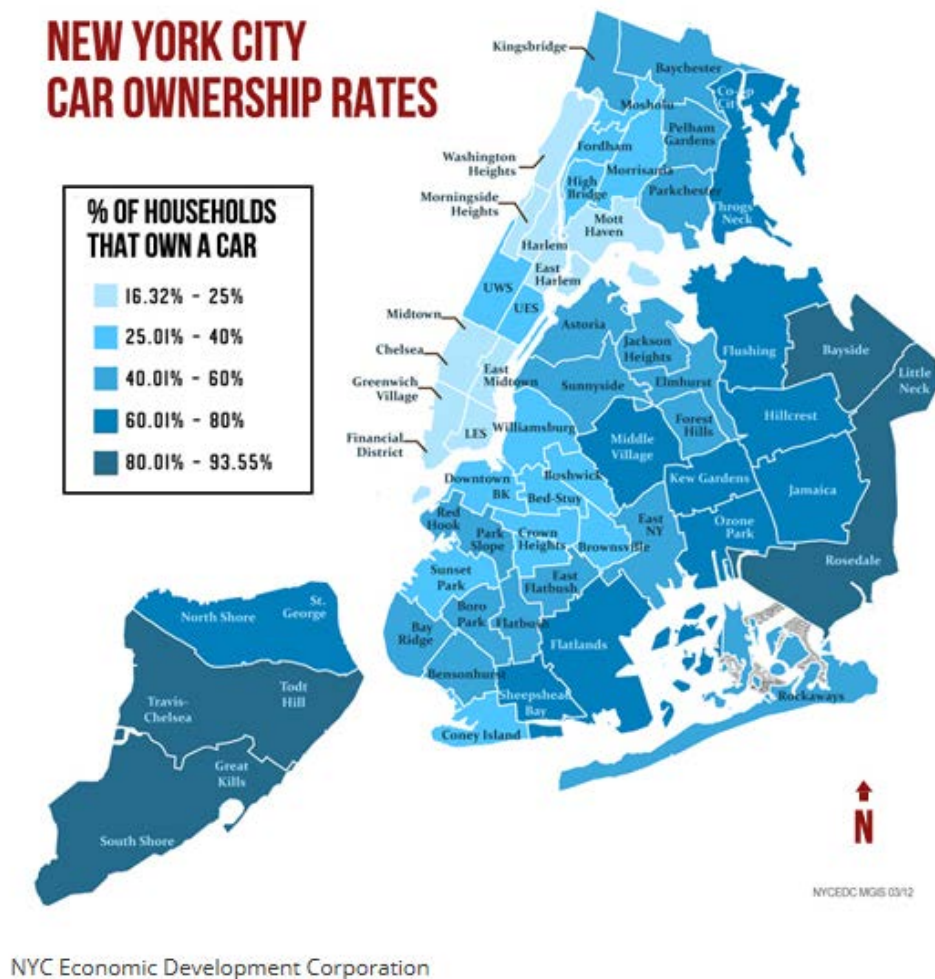
Source: U.S. Census (2000), Federal Transit Administration (2004)

¹⁰⁰ "The Mobility Factbook," NYU Rudin Center for Transportation, accessed September 4, 2016, <http://nycmobility.org/private-car>.

¹⁰¹ Source: Ibid.

The data in Table 6 directly conflicts with the map in Figure 4. NYC cannot be looked at as simply one city; population and road use differ greatly by borough. A monitoring, communication, and accountability model should be based on these issues so all populations receive prioritized improvements based on the needs of their area.

Figure 4. Car Ownership Rates in NYC¹⁰²



The map in Figure 4, when coupled with the NYC bridge crossing rates from Figure 5, indicates the needs of Staten Island residents to commute via private vehicle.

¹⁰² Source: Ibid.

The number of New Jersey residents commuting through Staten Island to get to other parts of NYC also needs to be taken into account. Both of these aspects determine a need for resilient roadways that are well maintained and monitored. This thesis recommends a model to account for differences in different boroughs.

Figure 5. Cars on Metropolitan Transit Authority Bridges and Tunnels, 2011¹⁰³

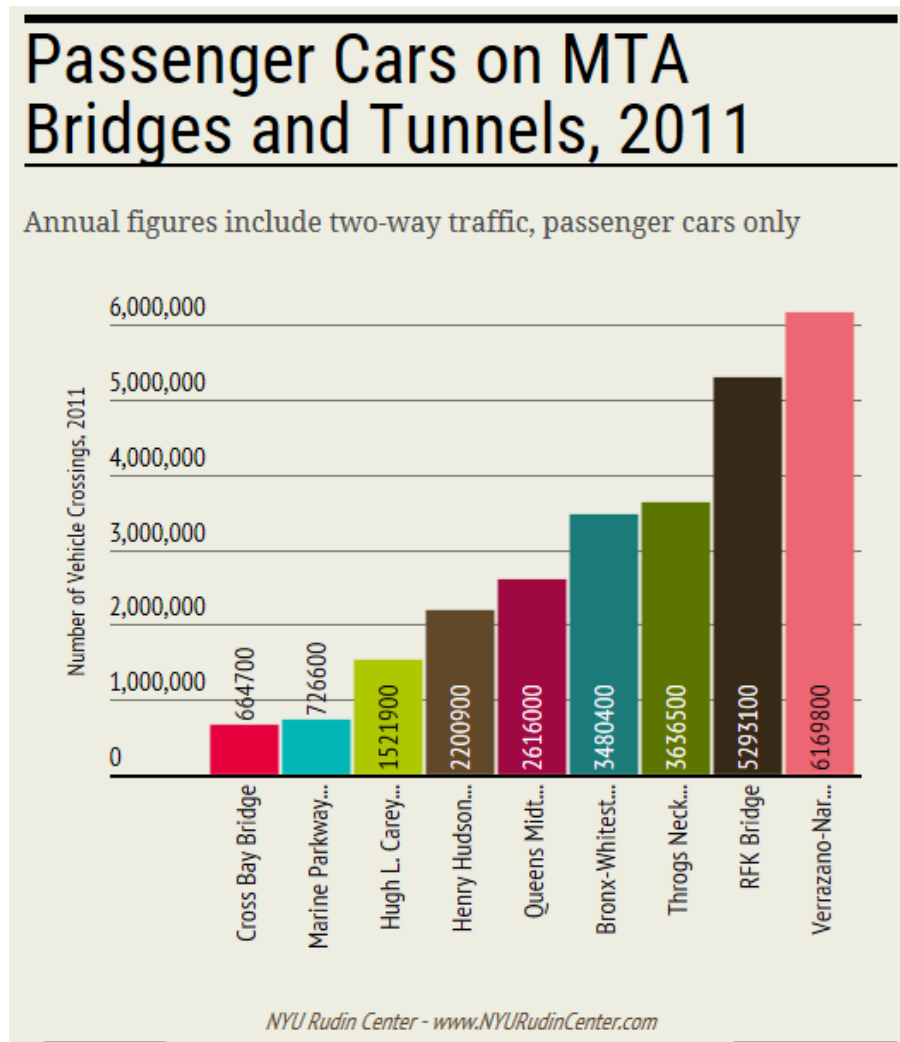


Figure 5 indicates travel over major NYC bridges, indicating the concern of Staten Island CI. The number of vehicles crossing the Verrazano Narrows Bridge yearly

¹⁰³ Ibid.

represents those of Staten Island residents as well as those commuting through Staten Island. Those vehicles arrive at the Verrazano Bridge via major highways, thoroughfares, and secondary roads, causing damage through use and causing delays while they use roads not intended for increased traffic. Roads need to be maintained in priority order by the respective agencies, and accountability must be ensured.

The Manhattan-based Center for an Urban Future is a public policy think-tank that details current issues with New York City's Infrastructure based on previous policy.¹⁰⁴ Their report, *Caution Ahead*, cites failures, such as the previous NYC administration promoting larger-scale projects and neglecting essential resurfacing, the resurfacing and funding gap, and the effect that commuting has on businesses in NYC. The connection between business opportunity and shifting populations, and the effect on CI relates back to TRIP's report regarding loss of tax revenue and future CI issues.

Caution Ahead details the policies of the Bloomberg administration that caused the CI deterioration currently experienced. Michael Bloomberg was the mayor of NYC and served three terms from 2002–2014.¹⁰⁵ An example of failure cited in *Caution Ahead* is the construction of New York City's first new water tunnel in 100 years while the Department of Environmental Protection fell behind its schedule for water main replacements.¹⁰⁶ This lapse in scheduling also occurred in street repaving.

The report describes a funding gap of \$3.2 billion dollars in the 2014–2017 capital needs for investment in New York City infrastructure but includes many facets not usually covered academically as infrastructure, such as public housing, hospitals, and prisons.¹⁰⁷ Citing only the Department of Transportation, the report indicates a \$789 million funding gap¹⁰⁸ for CI repairs, including the 30.4 percent of NYC roadways

¹⁰⁴ "About Center for an Urban Future," Center for an Urban Future, accessed September 4, 2016, <https://nycfuture.org/>.

¹⁰⁵ "Michael Bloomberg," Bio. July 28, 2016, <http://www.biography.com/people/michael-bloomberg-16466704>.

¹⁰⁶ Forman, Adam. "Caution Ahead: Overdue Investments for New York's Aging Infrastructure." *Center for an Urban Future* (2014).

¹⁰⁷ *Ibid.*, 49

¹⁰⁸ *Ibid.*

deemed in fair or poor condition.¹⁰⁹ Table 7 displays roadway conditions broken down by borough.¹¹⁰

Table 7. NYC Roads in Poor/Fair Condition¹¹¹

Borough	Fair/Poor Roads
Manhattan	43%
Staten Island	40%
Bronx	34%
Queens	31%
Brooklyn	28%

This thesis focuses on taking cited reports and collected intelligence and incorporating a communication model to create accountability and improvement. In analyzing the future, *Caution Ahead* shows that the New York City Department of Transportation is not meeting required goals to maintain roadways. The DOT “sets a goal of resurfacing approximately 1,000 lane miles of streets each year, but the agency has fallen short of that target on all but three occasions since Fiscal Year 2000 (FY2009, FY2011 and FY2012). During this period, it resurfaced an average of only 852 lane miles per year,”¹¹² as displayed in Figure 6

Failures and lack of reaching anticipated CI goals are well documented, yet they continue. Some reports issued yearly detail specifics but miss the follow-up phase that contributes to the success of the CompStat model. Information provided to the media by local politicians indicates the fiscal years 2014, 2015, and 2016 have also fallen below expectations, but a new initiative has allotted money to pave 1200 miles in 2016 and 1300 miles in 2017. The budget money allocated does not continue past 2017 and will

¹⁰⁹ Ibid.

¹¹⁰ Ibid.

¹¹¹ Ibid.

¹¹² Ibid.

have to be renegotiated back into the budget.¹¹³ Some sources indicate that setting the goal at 1000 lane miles still falls short, and a more appropriate schedule is 1,200 miles a year to prevent deterioration beyond useful life.

Figure 6. Resurfacing Gap, NYC Department of Transportation¹¹⁴

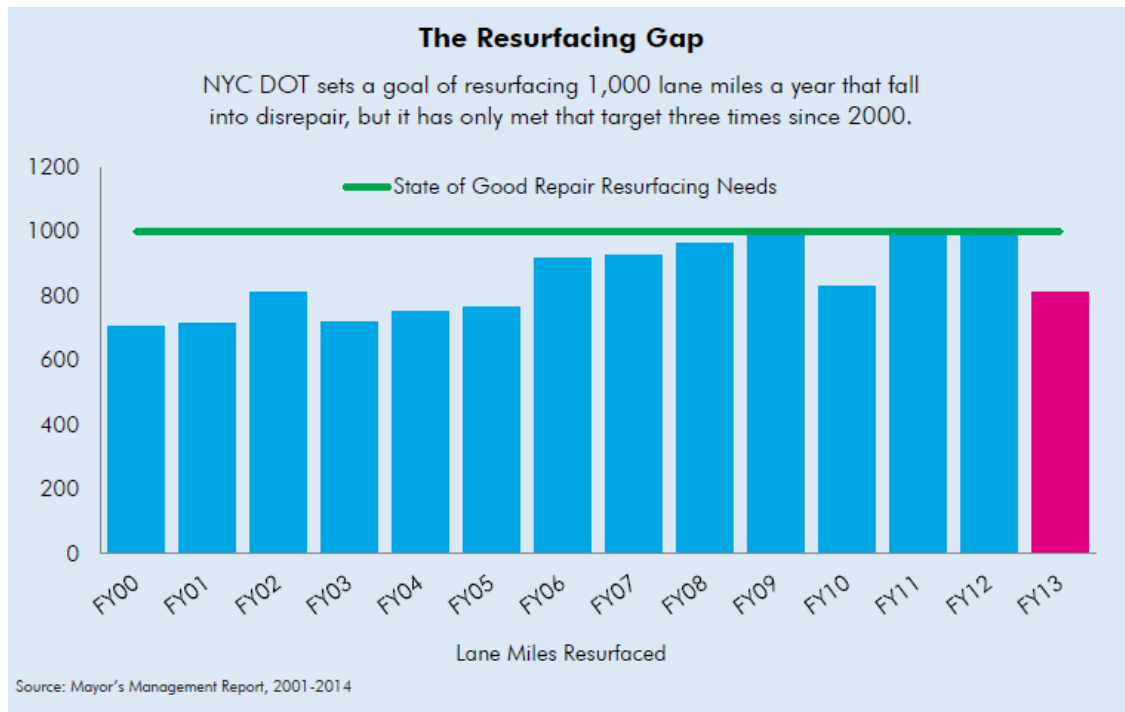


Figure 6 depicts the years in which the NYC DOT failed to meet their goal of repairing the targeted number of lane miles. This thesis examines how to take this information, correct the issues that cause the deficit, and ensure follow up.

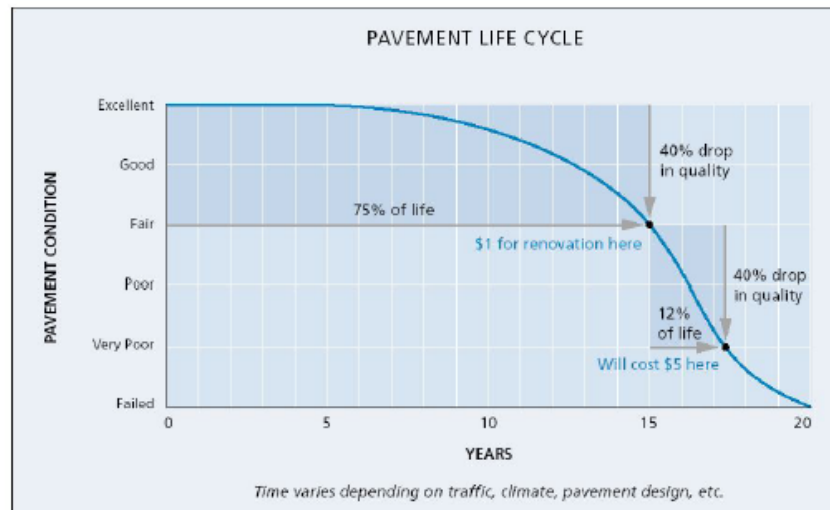
The pavement life cycle in Figure 7 demonstrates the importance of routine resurfacing, a pivotal CI issue. Without an accountability model, roads left to deteriorate past the fair rating will decline exponentially faster, costing more to fix. As depicted, paved roads have a surface life of approximately 15 years at which point they experience

¹¹³ Vincent Barone, “Smoother Island Roads! City Hikes paving miles by 52%,” *Staten Island Advance*, June 9, 2015, http://www.silive.com/news/index.ssf/2015/06/staten_island_woll_see_a_89_pe.html.

¹¹⁴ Source: Ibid.

a 40 percent drop in quality. In the next 2.5 years, roads experience and additional 40 percent drop, at which time the repair cost is five times what it would have been if the repairs had been done in a timely manner. The goal is to rate and repair roads promptly to avoid the extra costs associated.¹¹⁵

Figure 7. Pavement Life Cycle, Conditions, and Costs¹¹⁶



Source: Metropolitan Transportation Commission, "The Pothole Report," March 2000.

This thesis describes a model of communication and prioritization to prevent unnecessary deterioration. As discussed in this chapter, there is a cycle and a necessity to proper maintenance involving budgetary issues. In testimony to the New York City Council, Adam Forman, a research associate at Center for an Urban Future, highlighted the need to maintain and improve New York City infrastructure to continue attracting businesses. "With overcrowded subways, decrepit airport terminals, and potholed streets, talented individuals will leave the Big Apple, opting for San Francisco, London, or Hong Kong."¹¹⁷ Losing businesses and talented people to work in those companies lowers the

¹¹⁵ Shaller, "Choices at a Critical Junction," 14.

¹¹⁶ Source: Ibid.

¹¹⁷ Adam Forman, "A Call to Sustain New York's Economic Vitality by Improving Infrastructure," Center for an Urban Future, November 2014, <https://nycfuture.org/research/publications/a-call-to-sustain-new-yorks-economic-vitality-by-improving-infrastructure>.

tax base, widening the budget gap, extending the resurfacing gap, and causing greater issues with CI.

Studies reveal the effects of emergency incidents on transportation systems indicating that all modes of transport have not been maintained to the highest level possible, necessitating the need for rigorous follow-up on all projects. The Rudin Center for Transportation Policy and Management at New York University's Wagner School also explores challenges in transportation and infrastructure.¹¹⁸ As indicated in the Rudin Center's 2012 *Transportation Before and After Sandy*, major events cause shifts in transportation methods and commuting in New York City. The immediate travel times on days before and after Hurricane Sandy are shown to have doubled in most places, but almost tripled for Staten Island residents, as indicated in Table 8.¹¹⁹

Table 8. Commute Times, Pre- and Post-Hurricane Sandy¹²⁰

Residence Location	Pre-Sandy Commute Time (minutes)	Commute Time Nov. 1-2 (minutes)	Average Frustration Level
Brooklyn	42	86	3.93
Manhattan	29	52	2.97
Queens	45	47	3.00
Bronx	41	63	2.14
Staten Island	84	240	7.00
New Jersey	52	69	5.67
Northern Suburbs	73	61	2.40
Long Island	85	85	2.00

Figure 8 demonstrates how commuters changed their driving habits after Hurricane Sandy, including a 35 percent drop in subway travel resulting in a 1 percent increase in driving and taxi use, a 3 percent increase in bus usage, and a 7 percent

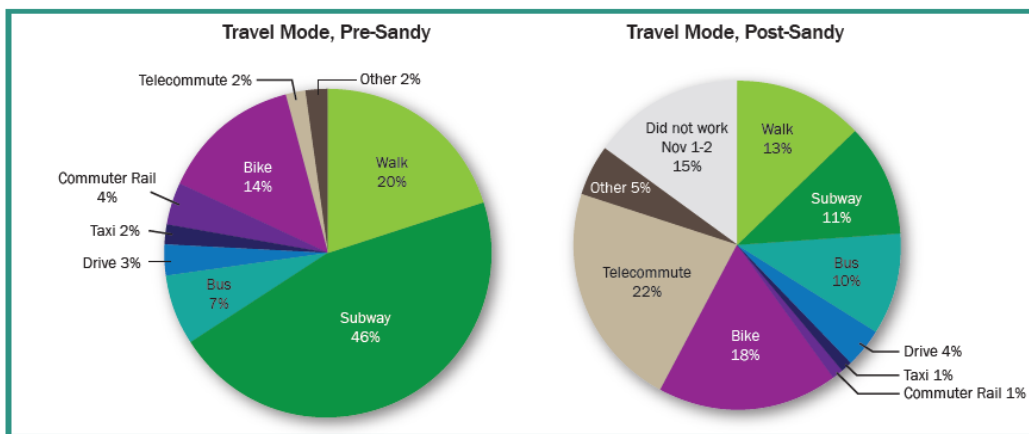
¹¹⁸ NYU Wagner Rudin Center for Transportation Policy & Management, "About the Rudin Center," accessed October 10, 2016, <http://wagner.nyu.edu/rudincenter/about/>.

¹¹⁹ Sarah Kaufman, Carson Qing, Nolan Levenson, and Melinda Hanson. "Transportation during and after Hurricane Sandy." (2012). Rudin Center for Transportation NYU Wagner Graduate School of Public Service

¹²⁰ Source: bid.

increase in walking.¹²¹ The drop in subway availability and usage caused an increase in bicycling, buses, and driving; all of which affect road conditions and are affected by road conditions.¹²² The concern in the 7 percent increase in walking will be discussed further in regard to personal injury claims against NYC due to street conditions. Improperly paved streets cause pedestrians to trip and repeated construction causes pedestrians to take different and occasionally dangerous routes.

Figure 8. Travel Modes, Pre- and Post-Hurricane Sandy¹²³



Reports address the New York City Department of Transportation’s failure to accurately track roadwork completed and its misrepresentation of improvements. The accountability and communication model presented in this thesis would promote transparency. New York City Comptroller, Scott Stringer, conducted an audit on the NYC DOT’s Tracking of Pothole Repairs to determine if the agency was adequately tracking pothole repair efforts. As one of the few examples of an audit or review of city agencies’ performance in regard to NYC CI, the report reveals the DOT’s denial of the findings of the audit and the methods used to conclude those findings. “DOT’s response

¹²¹ Marjorie Landa, *Management Audit: Audit Report on the Department of Transportation’s Tracking of Pothole Repairs*, City of New York Office of the Comptroller, June 29, 2016, http://comptroller.nyc.gov/wp-content/uploads/documents/ME15_114A.pdf.

¹²² Kaufman, Qing, Levenson, and Hanson. “Transportation during and after Hurricane Sandy.”

¹²³ Source: Landa, “Management Audit.”

contains a disconcerting number of inaccuracies regarding the audit's methodologies. In a number of instances... the agency presents scenarios that are simply inaccurate. This is of particular concern because they come from the agency's senior management, which should be familiar with the operations of its own agency."¹²⁴

Traffic engineering experts raise concerns regarding reports issued by the DOT. As the agency increases transparency, critics question the legitimacy of the numbers. Chapter V indicates the issues CompStat created with fraudulently inflating numbers, but as the technology and tracking of intelligence progresses, accuracy is increasing. Sam Schwartz was the New York City Traffic Commissioner, and the second in command of the Department of Transportation when the agencies merged. He has made a name for himself in public office and as the head of his engineering firm. Schwartz coined the term "gridlock" and is considered an expert in traffic-related issues. In August of 2016, the *New York Times* posted a story about the never-ending process of filling New York City potholes. The article quoted a traffic blog, *Daily Pothole*, and its recent count of 209,436 potholes filled as of August 8, 2016.¹²⁵ Schwartz, noticing the discrepancy stated, "Every administration has said they have filled more potholes than ever. The math doesn't always work out; 209,436 potholes had been filled this year as of Monday (8/29/16). That's about 40 potholes per hour, day and night, seven days a week."¹²⁶

City agencies, state agencies and private companies currently work in their own silos. This thesis focuses on collaboration of disciplines enabling sections, areas, and neighborhoods of the different boroughs to be repaired simultaneously regardless of who is responsible to maintain the property. In the *Audit Report on the Department of Transportation's Tracking of Pothole Repairs*, the NYC comptroller describes issues with DOT's tracking of pothole repairs. In a previous report, Comptroller Stringer identified the worst roadways in New York City for pothole-related vehicular damage

¹²⁴ Ibid.

¹²⁵ "The Daily Pothole – Mill & Pave," New York City Department of Transportation, August 8, 2016 <http://thedailypothole.tumblr.com/>.

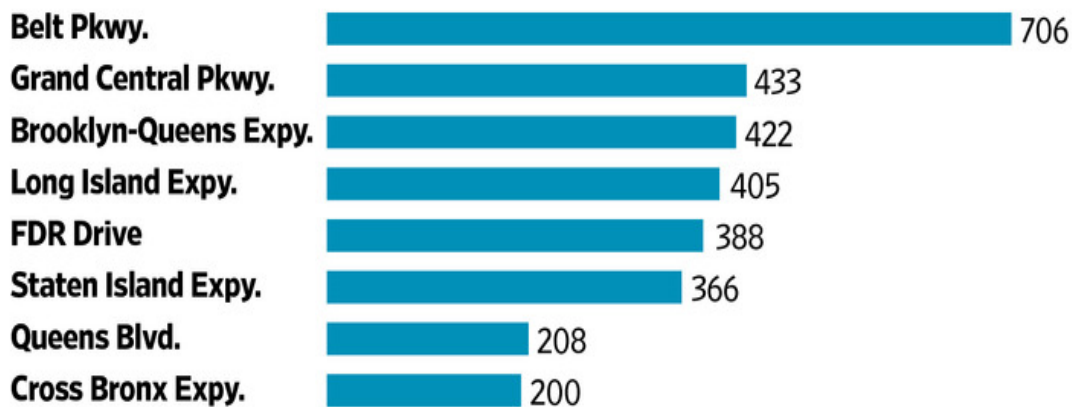
¹²⁶ Emily S. Rued, "Why Are The Streets Always Under Construction?," *New York Times*, August 8, 2016, http://www.nytimes.com/interactive/2016/08/18/nyregion/new-york-101-streets-repair-and-maintenance.html?_r=3.

and the amounts paid by the city for repairs.¹²⁷ Figure 9 describes the condition of roadways maintained by the NYSDOT as opposed to NYCDOT.

Figure 9. Roads with Most Vehicular Damage Claims¹²⁸

Rough Ride

Roads that generated the most vehicular damage claims during fiscal years 2010 to 2015, including intersections



The graph in Figure 9 indicates raw numbers of claims but fails to indicate that, while the Belt Parkway causes 28.2 damage claims per mile and the Brooklyn-Queens Expressway causes 12 claims, the Staten Island Expressway causes 48 damage claims per mile.¹²⁹ The road incidents that cause these events cause slower traffic as well as drivers moving to surface streets to avoid the damaged roads or traffic backup. New York City paid out substantial amounts of money for pedestrian injuries and vehicle damage resulting from defective roadways between July 2009 to July 2015. NYC paid \$1.5 million for 1,529 of the 12,286 claims filed for vehicle damage and \$138 million for 2,681 of the 5,913 claims filed for personal injury.¹³⁰ Unnecessary expenditures spent on

¹²⁷ Mozes Zarate, "Potholes Put a Dent in New York City Budget," *Wall Street Journal*, July 30, 2015, <http://www.wsj.com/articles/potholes-put-a-dent-in-new-york-city-budget-1438303741>.

¹²⁸ Source: bid.

¹²⁹ Ibid.

¹³⁰ Ibid.

injury and damage claims is better directed toward maintenance and improvement. A better method of repairing and maintaining roadways, as well as communication between the state DOT and city DOT, would reduce these claims.

Weather- and usage-related potholes are not the only CI issues with road surfaces. Underground CI maintenance and construction cause roadways to be pockmarked with patches. Mayor Bill DeBlasio's working group studied better procedures for underground critical infrastructure repair. The report issued develops strategies for communication between the city and the major utility providers. The report cites that "approximately 40% of all DOT street opening permits are issued to Con Edison [the local energy provider] or National Grid [the local natural gas provider] for work related to their utility networks."¹³¹ The strategies, however, do not address methods to ensure communication between city agencies.

The system of accountability recommended in this thesis requires private companies to be held accountable for inadequate work and communication to be established between city agencies and private companies. Street opening permits allow private utilities companies to open up pavement to do underground repair work to their systems. Currently, there are no criteria in place for how and when to conduct these openings, and more importantly, the size and type of closure required. As a vocal proponent for road repair, Staten Island Borough President James Oddo addresses this troubling issue in his social media briefings. Oddo noted that in 2003, New York City issued 116,000 permits to cut open a street. In 2015, the number almost doubled to 223,271.¹³² The borough president is a vocal critic of the DOT and pushed Mayor DeBlasio to increase street repaving to achieve Staten Island's share of the 1,000 lane miles paved each year. These cuts by the utility companies receiving 40 percent of the 223,000 permits cause weakened pavement, making them more susceptible to the abuses of snow, rain, freezing expanding water, and salt used for snow removal, thus, more

¹³¹ *Infrastructure Report*, City of New York, New York City Underground Infrastructure Working Group, (June 2014), 6, www1.nyc.gov/assets/home/downloads/pdf/press-releases/2014/infrastructure_report.pdf.

¹³² James Oddo's Facebook page, accessed September 3, 2016. <https://www.facebook.com/jamessoddofref=ts>.

potholes. On Monday, October 31, 2016, Borough President Oddo posted information to Facebook regarding a meeting he held with the DOT and National Grid, the local natural gas provider, regarding street cuts in newly paved protected streets. He mentioned, “our next meeting will include other utilities, as well as contractor industry representatives and other city agencies, namely the DEP.”¹³³ Is the monitoring of an asset as crucial as CI being overlooked by responsible city agencies, leaving it to local elected officials to develop a system of communication, collaboration, and accountability?

In addition to Hurricane Sandy, another emergency event tested Staten Island CI with frightening results of complete traffic shutdown on major thoroughfares and smaller secondary roads. On Friday, July 17, 2015, an emergency incident brought Staten Island traffic to a halt by a suspected terror threat. One day after the shooting in a military reserve center in Chattanooga, Tennessee, a retired police officer observed what looked like men and woman in Middle Eastern clothing loading rifles from one car to another. After he had called the police, a predictable massive response occurred. In an attempt to find the vehicles, all outgoing bridges were limited to one lane. The bridge closures caused a prolonged back-up on all highways, service roads, and major thoroughfares. “If there had been a real threat, if there actually had been a vanload of terrorists looking to shoot up the Island, or carrying a payload of explosives or biological weapons, we would have been screwed” stated one reporter. “Not only would Islanders have been sitting ducks, but the clogged roads would have prevented emergency responders from getting to the scene of any actual mayhem.”¹³⁴ The shutdown prevented escape and response. The purpose of this thesis is to ensure roads are maintained properly and move as smoothly as possible.

D. CONCLUSION

This chapter demonstrates the current state of roadway conditions in NYC and the recognized need to improve them. Those conditions impact Homeland Security in

¹³³ Ibid.

¹³⁴ Tom Wroblewski, “Terror and traffic: Staten Island on Edge,” *Staten Island Advance*, July 20, 2016, http://www.silive.com/opinion/columns/index.ssf/2015/07/terror_and_traffic_staten_isla.html.

different ways. First, in a post-9/11, post-Hurricane Katrina, post-Hurricane Sandy environment, escape routes and emergency vehicle access is dependent on both the conditions of the roadways and the timeliness of repairs. Second, appropriate use of tax dollars must be a top concern to prevent any misappropriation. Third, organizations interested in cleaner transportation must take into account ways in which to make commuting more cost efficient and environmentally conscious. A method of ensuring communication and accountability can start in NYC and then develop to other geographic areas. Currently, there are accountability lacks within city agencies and communication lacks between city agencies. The next chapter provides specific incidents of communication failures between NYC agencies as reported through local media and politicians' social media. The failures and the resulting actions duplicated work, caused traffic delays, and wasted taxpayers' money.

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IV. SAMPLE EVENTS

Chapter III examined many issues with New York State Critical Infrastructure (CI), specifically focusing on New York City. Chapter IV contains sample events taken from local media sources, elected officials' reports, and personal observation, all of which demonstrate the severe effects of lack of communication between city agencies, including poor repairs, wasted taxpayer money, and delays in substantial genuine improvement to critical infrastructure. The goal of listing these sample events is to identify the need for pre-event, pre-construction communication to determine a correct course of action, ensuring this communication assists in developing and testing any post-event plans necessary in cases of evacuation and emergency response. This chapter lists events in order of increasing collaboration required: failures of city agencies to communicate with each other, followed by city agency/state agency failures, then city agency/federal agency failures, and finally, post-emergency event communication failures.

A. ARTHUR KILL ROAD WIDENING

Arthur Kill Road, a main thoroughfare in Staten Island, is an example of the lack of communication between the DOT and the Parks Department, as well as the exclusion of other stakeholder agencies. The widening of Arthur Kill Road impacted emergency traffic and wasted taxpayer dollars. The Brookfield Landfill is adjacent to Arthur Kill Road and was one of five New York City landfills illegally used between 1974 and 1980.¹³⁵ In 1982, a New York City Department of Sanitation official and a private sanitation hauler wound up incarcerated after the federal government investigated the illegal dumping.¹³⁶ In 1990, New York City set \$600 million aside for the cleanup of the five facilities.¹³⁷ The city began work on four of the five locations, neglecting the fifth

¹³⁵ "Staten Islanders Sue For Toxic Waste Cleanup," Earth Justice, October 14, 2008, <http://earthjustice.org/news/press/2008/staten-islanders-sue-for-toxic-waste-dump-cleanup>

¹³⁶ Ibid.

¹³⁷ Ibid.

site, the 272-acre Brookfield Landfill in Staten Island.¹³⁸ In 2008, residents near the Brookfield Landfill filed suit in Manhattan Federal Court to force the city to clean up the site. The residents were successful, and in 2009, New York City allotted \$141 million for cleanup.¹³⁹ After some setbacks, remediation began in 2010. By mid-2012, NYC scheduled Brookfield Park for a 2017 completion, but the expected price rose to \$266 million.¹⁴⁰ Figure 10 shows an aerial view of the Brookfield site including its borders, Richmond Avenue and Arthur Kill Road.

Figure 10. Aerial View of Brookfield Park¹⁴¹



¹³⁸ “Brookfield Landfill: Cleaning Up a Toxic Dump,” Earth Justice, accessed September 9, 2016, http://earthjustice.org/our_work/cases/2008/brookfield-landfill-cleaning-up-a-toxic-dump#.

¹³⁹ “City Budgets \$141 Million for Toxic Waste Cleanup at Staten Island Site,” Earth Justice, June 18, 2009, <http://earthjustice.org/news/press/2009/city-budgets-141-million-for-toxic-waste-cleanup-at-staten-island-site>.

¹⁴⁰ Mark Stein, “Former Brookfield Landfill on Staten Island Being Transformed,” *Staten Island Advance*, October 27, 2012, http://www.silive.com/eastshore/index.ssf/2012/10/former_brookfield_landfill_on.html.

¹⁴¹ Adapted from Google Maps, “Brookfield Landfill.” Accessed September 9, 2016. <https://www.google.com/maps/place/Arthur+Kill+Rd,+Staten+Island,+NY/@40.5640205,-74.1571289,1126m/data=!3m1!1e3!4m5!3m4!1s0x89c24adc72a56fb1:0xa075b2c456c84349!8m2!3d40.5558469!4d-74.2016273?hl=en>.

The Brookfield Landfill, as it transitions into the Brookfield Park, abuts Arthur Kill Road, a narrow winding roadway slated for widening due to traffic congestion. As both projects—the widening of the road and building of the park—overlap, the lack of communication between city agencies wasted time and tax dollars with unnecessary projects completed and scheduled for removal at completion. In this area, Arthur Kill Road is a two-lane road (one lane in either direction). The proposal of widening the road gained momentum in 2012 when a new NYC mayor, Bill DeBlasio, was elected.¹⁴² In late 2012, Staten Island borough president James Oddo presented the proposal to Mayor DeBlasio, who accepted the merit of the idea.¹⁴³ The proposal was discussed at length until early 2015, when Mayor DeBlasio allotted \$15 million for completion of the project.¹⁴⁴ Although 18 months later—at the time of the writing of this thesis—the project has not commenced, the adjacent Brookfield Park has new trees planted directly inside the newly installed fence, all of which are slated for removal when DOT widens Arthur Kill Road. Figure 11, similar to Figure 10, shows the aerial view but also depicts the area of proposed widening.

¹⁴² Vincent Barone, “Mayor Allocates \$15 Million for Arthur Kill Road Expansion,” *Staten Island Advance*, May 7, 2015, http://www.silive.com/southshore/index.ssf/2015/05/mayor_allocates_15_million_for.html.

¹⁴³ Ibid.

¹⁴⁴ Ibid.

Figure 11. Aerial View of the Proposed Widening of Arthur Kill Road¹⁴⁵



Figure 12 shows a street-level view of approved street widening, noting new trees planted and the replaced fence along the inside of the fence line, which will have to be removed to widen the road. The red area will become the right lane of southbound traffic, necessitating sidewalk and new fencing to be placed past that area.

Figure 12. Street-Level View of Approved Widening¹⁴⁶



¹⁴⁵ Source: Ibid.

¹⁴⁶ Source: Ibid.

A system of communication established between city agencies would enable discussion to prevent unnecessary projects and, on a larger note, to ensure limited resources are properly utilized. The unnecessary work demonstrates a need for multi-agency collaboration and an accountability model. The Department of Environmental Protection (DEP) “holds monthly meetings with the Brookfield Landfill Citizens Advisory Committee, a board of volunteers that works in close collaboration with the department on oversight for the remediation of the Brookfield Landfill.”¹⁴⁷ Representatives designated by Community Board 3 and from the offices of Representative McMahon, the Staten Island borough president, the New York State Assembly, the State Senate, and the City Council comprise the committee.¹⁴⁸

The NYC DEP is overseeing the remediation process, but the meetings and committees listed fail to include the New York City Parks Department, which is tasked with the planting of the trees and installation of the fences, or the Department of Transportation (DOT), which could have provided information on the future street widening process.

B. BAY TERRACE, STATEN ISLAND, WATER RUNOFF

Good f**cking luck, Captain, getting DEP and DOT to work together.

—DEP Supervisor, Personal Communication

Recently, there has been a lack of initiative and collaboration between the NYC DOT and the NYC Department of Environmental Protection (DEP) with continuing storm drainage issues, which destroyed streets, curbs, sidewalks, and other personal property in Staten Island. Storm drainage issues create hazardous conditions for emergency response and cost citizens money due to improper maintenance and improvement of CI. Beginning in 2004, residents of Twombly Avenue, in the Bay Terrace section of Staten Island, began making complaints to various city agencies

¹⁴⁷ New York City Environmental Protection, “Brookfield Landfill Remediation, accessed September 9, 2016, http://www.nyc.gov/html/dep/html/dep_projects/cp_brookfield_landfill.shtml.

¹⁴⁸ Ibid.

regarding damage from water runoff due to improper street grading and lack of a correctly positioned storm drain. The author came face to face with this issue, as a resident requesting collaboration from city agencies to perform a necessary repair. As shown in Figure 13, the sea-level elevation of the marked locations pitches water runoff from the Staten Island Rapid Transit (SIRT) tracks to Twombly Avenue from 82 feet to 56 feet, respectively. The marked area at the northwest corner of Twombly Avenue and Hopkins Avenue does not have a catch basin for water runoff, and the marked pedestrian crosswalk is at a greater elevation than the street elevation immediately to the northwest, causing water to pool along the curb line for approximately 200 feet. This pooling of water deteriorated curbs and sidewalks, causing the issuance of violations to homeowners by the Department of Finance, as well as deterioration of the road asphalt. Figure 13 also shows the indicated elevation above sea level and key aspects of the complaints, as measured by the author.

Figure 13. Aerial Image of Bay Terrace Section of Staten Island¹⁴⁹



¹⁴⁹ Adapted from "Bay Terrace State Island," Google Maps, accessed September 9, 2016, <https://www.google.com/maps/@40.558286,-74.1334856,140m/data=!3m1!1e3?hl=en>.

Residents cited the need for a catch basin to be positioned correctly on Twombly Avenue to the west of the intersection with Hopkins Avenue. The current placement was only eight feet away on Hopkins Avenue just north of Twombly Avenue. Residents witnessed a DEP engineer test the water flow southbound on Hopkins Avenue from the indicated fire hydrant. The engineer reported to the DEP that there was no water flow problem. The residents grew more frustrated due to the DEP's inattention to details. A careful communication process between all agencies and private companies might have rectified residents' complaints.

During a work-related assignment as a NYPD captain, the author of this thesis was present with a supervisor from the DEP. The author and the DEP supervisor discussed the water flow issue and the need for the DEP to install a catch basin and then have the DOT grade and repave the street. During a personal communication with the author, the DEP supervisor then stated, "Good f**king luck, Captain, getting DEP and DOT to work together." Multiple requests for cooperation were ignored by city agencies and hopes of all work being completed correctly on an appropriate schedule vanished, leaving residents to push local elected officials to get involved, which resulted in street repaving in 2006. A model of communication and follow-up could have prioritized work to save taxpayer money and create a safer living environment.

In 2014, the New York City Department of Design and Construction hired contractors to replace the sidewalks and curbs of the residents who received violations, billing the homeowner for the replacements. After ten years of complaints and damage, the city agency involved, DOT, addressed the issue. The work was improperly performed and caused damage to property, a situation that is currently in litigation. Beginning in March 2016, the Department of Design and Construction began a capital project to address water flow issues, which included installing catch basins on South Railroad Avenue to prevent water from flowing through residents' properties and on Twombly Avenue west of Hopkins, to properly drain water running along the curb on Twombly Avenue. Figure 14 shows the scope of the project, and Figure 15 describes the work.

Figure 14. Department of Design and Construction Capital Projects¹⁵⁰

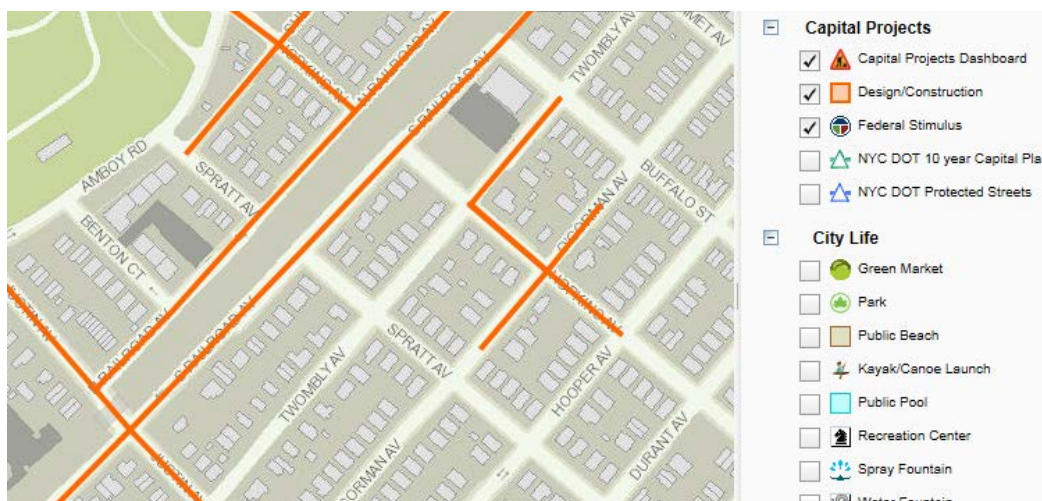


Figure 15. Department of Design and Construction Capital Projects¹⁵¹



As of October 2016, the project is still under construction and the newly installed storm drains have been elevated, preventing water from flowing into them as shown in Figure 16. However, this is a temporary fix that has actually worsened conditions for the past seven months. As the issue continues, the NYC Department of Health is involved due to the standing water, which breeds mosquitos. West Nile Virus is a common fear in the summer, but the summer of 2016 also added the Zika virus to the list of concerns. The Department of Design and Construction, in their lack of response to complaints and lack

¹⁵⁰ Source: “NYCityMap,” New York City Office of Information Technology & Telecommunications, accessed November 8, 2016, http://gis.nyc.gov/doitt/nycitymap/template.jsp?z=4&p=991201,192667&c=GISBasic&f=DDC_PROJECTS.

¹⁵¹ Source: Ibid.

of communication, added more problems to existing ones. A multi-agency oversight organization, allowing public viewing and input, could have resolved issues more quickly with less money wasted.

Figure 16. New Installation of Storm Drain on the Corner of Twombly Avenue and Hopkins Avenue



C. EASTERN PARKWAY

A third communication failure risked pedestrian safety and wasted money when the NYC DOT failed to consult the NYPD and neighborhood civic organizations before removing recently installed pedestrian safety devices in the Crown Heights section of Brooklyn. Eastern Parkway was labeled as the fourth highest intersection in NYC in 2012 for pedestrian fatalities.¹⁵² Due to those fatalities and other injuries, in late 2015 the DOT installed the pedestrian islands shown in Figure 17.¹⁵³

¹⁵² “High Pedestrian Crash Locations - 2012,” New York City Department of Transportation, retrieved October 11, 2016, <http://www.nyc.gov/html/dot/downloads/pdf/2012-nyc-top-20-pedestrian-crash-locations.pdf>.

¹⁵³ Rachael Holliday Smith, “City Rips Up New Eastern Pkwy Pedestrian Islands For West Indian Day Parade,” DNA Info. August 30, 2016, <https://www.dnainfo.com/new-york/20160830/crown-heights/city-rips-up-new-eastern-pkwy-pedestrian-islands-for-west-indian-day-parade>.

Figure 17. Pedestrian Island—Eastern Parkway¹⁵⁴



Photo Credit: Angel Chevestt

The lack of communication prior to installation caused neighborhood issues to be overlooked; once installed, the removal of the pedestrian island endangered the pedestrian community and closed off the thoroughfare during reconstruction. Eastern Parkway is the location of the annual West Indian Day Parade on Labor Day Weekend. The parade consists of Caribbean-costumed participants and flatbed tractor-trailers with bands and speakers. Before the 2016 parade, the DOT removed the pedestrian island, causing traffic build-up and limiting response to potential emergencies, as indicated in Figure 18.¹⁵⁵

¹⁵⁴ Source: Ibid.

¹⁵⁵ Ibid.

Figure 18. Eastern Parkway Pedestrian Island Removal¹⁵⁶



Photo Credit: Rachael Holliday Smith

Scott Gastel, a spokesman for the NYC DOT stated “the concrete islands were removed due to safety concerns involving parade participants and large vehicles.”¹⁵⁷ Gastel added, “we are looking at potential replacement treatments in the area and for the long term.”¹⁵⁸ In addition to the short-term construction issues, the removal sparked community outrage with one resident stating, “The parade is one day out of the year. The main thing is the pedestrians, the kids and the schoolchildren.”¹⁵⁹ The controversy regarding the pedestrian islands has supporters on the pedestrian safety side as well as the parade organizers side. The recommendation of this thesis is to study issues more carefully and have an open forum for communication to prevent removal of vital infrastructure 10 months after placement.

¹⁵⁶ Source: Ibid.

¹⁵⁷ Ibid.

¹⁵⁸ Dean Balsamini, “City to Destroy Safety Barriers for West Indian Day Parade Floats,” *New York Post*, August 28, 2016, <http://nypost.com/2016/08/28/city-to-destroy-safety-barriers-for-west-indian-day-parade-floats/>.

¹⁵⁹ Smith, “City Rips Up New Eastern Pkwy Pedestrian Islands for West Indian Day Parade.”

D. SUPERSTORM SANDY BUYOUT AND REBUILDING

Another example of communication breakdown between the NYC DOT and the NYC Parks Department involved New York State agencies as well. New York State purchased Superstorm Sandy ravaged land on Staten Island, turning it into park land for the NYC Parks Department. The DOT paved the streets on that land as routine scheduled roadwork. Hurricane Sandy made landfall on October 29, 2012, at approximately 8 pm EST in Atlantic City, New Jersey, just 125 miles south of Staten Island, New York. The storm began a week earlier in the Caribbean and upgraded and downgraded numerous times before hitting New York and New Jersey with 80-mile-an-hour sustained winds and 14-foot waves.¹⁶⁰ Sandy is responsible for 42 deaths in New York, 12 in New Jersey, and many others in the continental United States.¹⁶¹ The Federal Emergency Management Agency (FEMA) estimates the damage at approximately \$50 billion.¹⁶²

Waves devastated the Ocean Breeze beach front section of Staten Island as indicated in Figures 19 and 20. Figure 19 shows a map of the area and Figure 20 shows a satellite image of the same area. Figure 20 depicts the area regarding proximity to the water, clusters of houses, and the surrounding empty land.

¹⁶⁰ John Rafferty, "Superstorm Sandy," Encyclopedia Britannica, Last updated May 31, 2016, <https://www.britannica.com/event/Superstorm-Sandy>.

¹⁶¹ Ibid.

¹⁶² Tim Sharp, "Superstorm Sandy: Facts About the Frankenstorm," LiveScience, November 27, 2012, <http://www.livescience.com/24380-hurricane-sandy-status-data.html>.

Figure 19. Street Map of Ocean Breeze, Staten Island¹⁶³

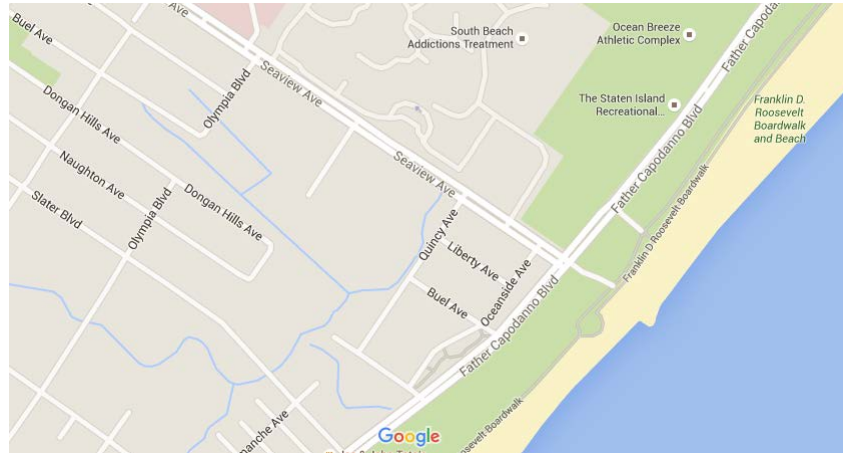


Figure 20. Satellite Map of Ocean Breeze, Staten Island¹⁶⁴

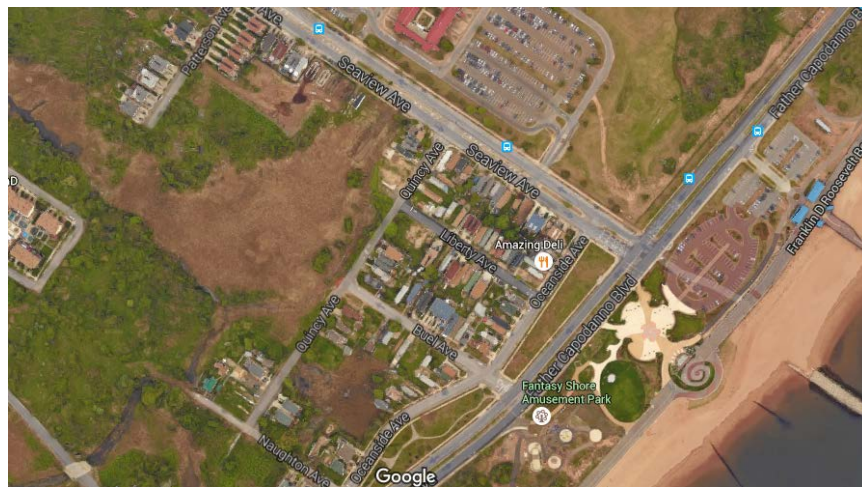


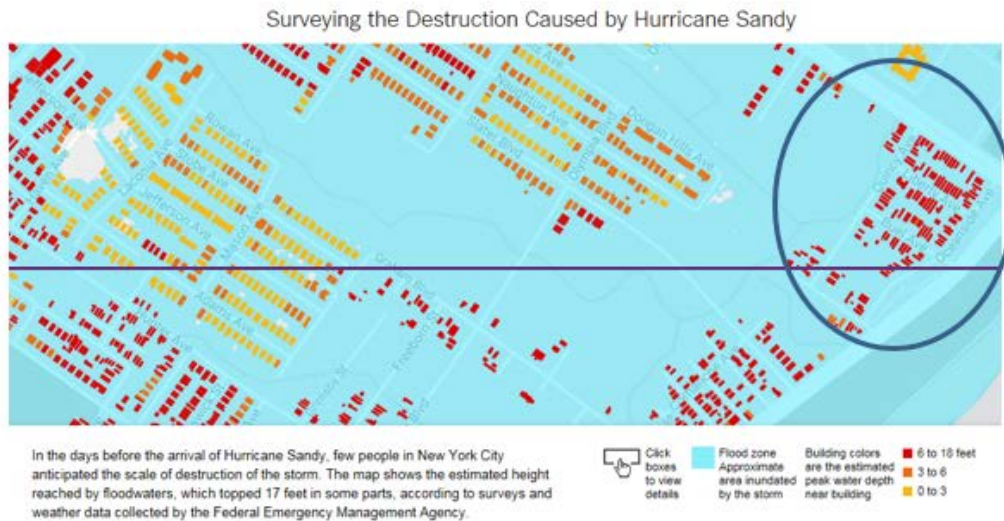
Figure 21 shows 6–18-foot waves, the highest reported in NYC, hitting the area and causing destruction to some homes and significant damage to others, but all homes in

¹⁶³ Source: “South Beach, Staten Island Map View,” Google Maps, accessed September 9, 2016, <https://www.google.com/maps/place/Liberty+Ave,+Staten+Island,+NY/@40.5790106,-74.0807927,16z/data=!4m5!3m4!1s0x89c24ec520d75279:0xd6da8bb73021cd22!8m2!3d40.5841604!4d-74.0891183>.

¹⁶⁴ Source: “South Beach, Staten Island Satellite View,” Google Maps, accessed September 9, 2016, <https://www.google.com/maps/place/Liberty+Ave,+Staten+Island,+NY/@40.5790106,-74.0807927,1127m/data=!3m1!1e3!4m5!3m4!1s0x89c24ec520d75279:0xd6da8bb73021cd22!8m2!3d40.5841604!4d-74.0891183>.

the area were affected.¹⁶⁵ As indicated in Figure 21, the circled area was assaulted by 6–18-foot waves, leaving behind significant damage and destruction.

Figure 21. Map of Flood Zone, Ocean Breeze, Staten Island¹⁶⁶



New York State Governor Andrew Cuomo declared a state of emergency after the storm, and, one year later, announced government funded buyouts of over 100 houses.¹⁶⁷ The buyout replaces destroyed homes with parkland and creates a barrier between the ocean and houses farther inland. Barbara Brancaccio, the spokeswoman for the Governor’s Office of Storm Recovery, stated, “It’s really a resiliency program, we are going to get you out of here, because it’s dangerous, and we’re also going to make it safer for everybody else through this natural buffer.”¹⁶⁸

¹⁶⁵ Matthew Bloch, Ford Fessenden, Alan McLean, Archie Tse and Derek Watkins, “Surveying the Destruction Caused by Hurricane Sandy,” *New York Times*, accessed September 9, 2016, <http://www.nytimes.com/newsgraphics/2012/1120-sandy/survey-of-the-flooding-in-new-york-after-the-hurricane.html>.

¹⁶⁶ Source: Ibid.

¹⁶⁷ “Cuomo Announces Buyouts for Sand-Decimated Staten Island Homeowners,” NBC News, November 18, 2016, <http://newyork.cbslocal.com/2013/11/18/gov-cuomo-announces-buyouts-for-ocean-breeze-homeowners/>.

¹⁶⁸ Nathan Kensinger, “Residents Retreat From Staten Island’s Hard-Hit Waterfront,” *Curbed New York*, October 29, 2014, <http://ny.curbed.com/2014/10/29/10029950/residents-retreat-from-staten-islands-hard-hit-waterfront>.

Six months later, in April 2014, the NYC DOT announced plans to repave the streets in the Ocean Breeze section. After community and political outrage, the outspoken Borough President of Staten Island, James Oddo, said, “This is simply ridiculous. Next time a crotchety senator or congressman rants on and on about not wanting to provide New York with federal money, they will point to things like this.”¹⁶⁹

The Department of Transportation completed the road resurfacing project in the affected area, Liberty Avenue, on June 20, 2014, and informed Borough President Oddo of another street with the same situation in the nearby Midland Beach section, street resurfacing on Baden Avenue in Midland Beach on May 5, 2014, as displayed in Figure 22.¹⁷⁰

Figure 22. Department of Transportation Protected Streets Listing¹⁷¹

On Street	From Street	To Street	Address Low	Address High	Completed Date	Protected Until	Boro
LEVERETT AVENUE	POMPEY AVENUE	WAINWRIGHT AVENUE	706	770	7/20/2015	7/19/2020	Staten Island
LEVERETT AVENUE	RICHMOND AVENUE	WAINWRIGHT AVENUE	652	704	7/20/2015	7/19/2020	Staten Island
LEVERETT AVENUE	RIDGEWOOD AVENUE	SWEETBROOK ROAD			7/16/2015	7/15/2020	Staten Island
LIBERTY AVENUE	OCEANSIDE AVENUE	QUINCY AVENUE	701	747	6/20/2014	6/20/2019	Staten Island
LILAC COURT	FOREST AVENUE	GARRICK STREET			10/21/2013	10/21/2018	Staten Island
LINCOLN AVENUE	BADEN PLACE	COLONY AVENUE	591	613	8/15/2012	8/15/2017	Staten Island

On Street	From Street	To Street	Address Low	Address High	Completed Date	Protected Until	Boro
ASTOR AVENUE	BEND	DEAD END	1	99	6/19/2013	6/19/2018	Staten Island
ASTOR AVENUE	STATEN IS EP EB EN LAMBE	BENDLA	0	0	6/19/2013	6/19/2018	Staten Island
BADEN PLACE	DEAD END				5/5/2014	5/5/2019	Staten Island
BADEN PLACE	DEAD END	GREELEY AVENUE	350	398	5/5/2014	5/5/2019	Staten Island
BAILEY PLACE	DEAD END	NORTHFIELD AVENUE	2	82	10/2/2013	10/2/2018	Staten Island
BALLARD AVENUE	WOODROW ROAD	SPERRY PLACE	2	98	11/23/2016	11/23/2021	Staten Island

¹⁶⁹ Judy Randall, “City DOT Milling, Paving Streets in Sandy Buy-out Neighborhoods,” *Staten Island Advance*, April 16, 2014, http://www.silive.com/news/index.ssf/2014/04/city_dot_milling_paving_street.html.

¹⁷⁰ “Protected Streets Listing,” City of New York City, accessed September 9, 2016, <http://www.nyc.gov/html/dot/downloads/pdf/segallboro.pdf>.

¹⁷¹ Adapted from Ibid.

E. GATEWAY NATIONAL PARK

The lack of communication, collaboration, and accountability between NYC and federal agencies demonstrates the need for improved focus. The National Park Service (NPS) oversees Gateway National Park but is not maintaining the land that abuts land that falls within NYC Parks Department, NYC Metropolitan Transit Authority (MTA), and NYC DOT property. Although this has no direct threat or effect on homeland security, national and city parks are listed as infrastructure and received a C-rating nationally in the American Society of Civil Engineers (ASCE) ratings provided earlier. The lack of communication between city agencies and the federal government displayed in this event is problematic; allowing property conditions to degrade due to lack of accountability wastes taxpayer money and frustrates residents.

Gateway National Park and Great Kills Beach, located south of Hylan Boulevard in Staten Island, have been maintained by the National Park Service since 1972. In 2014, residents complained to local elected officials regarding the deteriorating condition of the park and garbage accumulation. Officials held a press conference at the location after letters and requests were not answered by the respective agencies. Congressman Michael Grimm delineated the agencies and property responsibilities to the attendees.¹⁷² Councilman Vincent Ignizio joined Congressman Grimm and added, “Clearly, government is not working properly. It’s a filthy mess,”¹⁷³ and “Let’s sit around the table and come up with a solution that will keep this place clean,”¹⁷⁴

This thesis recommends an accountability and communication model, similar to the NYPD’s CompStat model, to promote, foster, and ensure that exact process results in improved critical infrastructure. Figure 23 depicts the adjacent property of agencies involved.

¹⁷² Kiamwa Rich, “Staten Island Elected Officials Call on Government to Clean Up Garbage in Bay Terrace,” Staten Island Advance, April 14, 2014, http://www.silive.com/news/index.ssf/2014/04/staten_island_elected_official_9.html.

¹⁷³ Ibid.

¹⁷⁴ Ibid.

Figure 23. Gateway National Park Entrance¹⁷⁵

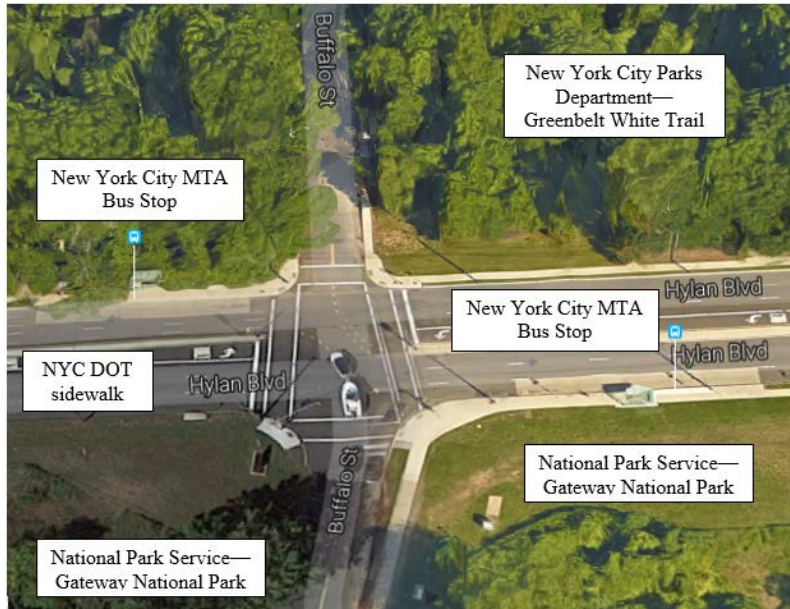


Figure 23 depicts the four agencies involved in this intersection. Getting those four agencies to collaborate would create a safer, cleaner neighborhood. An accountability model would ensure all agencies are maintaining their respective property.

F. HYLAN BOULEVARD—STATEN ISLAND EXPRESSWAY DETERIORATION

Previous sample events detailed failures in communication between city agencies, then between city and state agencies, and finally between city and federal agencies, but all were prior to emergency events, focusing on repair and maintenance. This thesis recommends agency collaboration overseen by the Deputy Mayor of Infrastructure in conjunction with Emergency Management (NYC EM), which is currently tasked with only post-emergency multi-agency collaboration.

¹⁷⁵ Adapted from “Great Kills Park, Staten Island Satellite View,” Google Maps, accessed October 11, 2016, <https://www.google.com/maps/place/Great+Kills+Park/@40.5552261,-74.1261318,228a,20y,313.34h,45t/data=!3m1!1e3!4m5!3m4!1s0x89c24bd5dc4a0f23:0xd7a54d9d9efca532!8m2!3d40.5502073!4d-74.1269322?hl=en>.

The next event depicts failures in post-emergency event communication. The NYC DOT's inadequate repair work to the Hylan Boulevard overpass on the Staten Island Expressway caused a second deterioration six years later, resulting in long-term construction and traffic issues, both of which affect general and emergency transportation. Hylan Boulevard passes over the Staten Island Expressway in two locations—one northbound and one southbound—at the northernmost end of the Staten Island Expressway before the Verrazano Bridge. See Figure 25. The northbound lane services 8300 vehicles daily and the southbound, 8,800. In late April 2009, deterioration of the roadway of the northbound lane caused baseball-sized concrete pieces to rain down onto the Staten Island Expressway 25 feet below. The falling concrete caused closure of the eastbound Staten Island Expressway for hours as the fire department placed emergency netting under the overpass. The overpass itself was closed for days afterward to repair the nine-inch hole in the roadbed with exposed rebar, as shown in Figure 24. The cause was determined to be freezing winter weathers and use of salt to melt ice and snow. The investigation revealed that neighborhood residents had complained about the widening hole for weeks prior.¹⁷⁶

¹⁷⁶ Phil Helsel, "Falling Debris Creates Dangerous Condition on the Staten Island Expressway," *Staten Island Advance*, April 27, 2009, http://www.silive.com/news/index.ssf/2009/04/overpass_debris_causes_danger.html.

Figure 24. Broken Concrete and Exposed Construction Rebar¹⁷⁷



Photo Credit: Hilton Flores

Figure 25. View of Northbound Hylan Boulevard Overpass¹⁷⁸



Photo Credit: Hilton Flores

¹⁷⁷ Source: Ibid.

¹⁷⁸ Source: Ibid.

On June 3, 2015, State Senator Kirsten Gillibrand cited a New York State Department of Transportation report noting 74 percent of Staten Island's highway bridges are either "functionally obsolete" or "structurally deficient."¹⁷⁹ Eight days later, a hole opened up in the same location that was previously addressed in 2009. The NYS DOT immediately began a project to replace the decking of the overpass, which had been slated for repair at an unspecified date and was estimated to cost \$10 million.¹⁸⁰ Local elected officials were outraged over the decision that caused hours of delays of the uninformed public, also giving emergency responders no time to prepare for traffic control and emergency response. An agreement was reached to postpone the project for three weeks until after July 4. On June 22, 2015, a second hole opened in a different portion of the roadway. DOT covered the section with a steel plate in anticipation of the upcoming full-scale construction.¹⁸¹

The initial deterioration was due to inadequate CI upkeep. After the discovery of the first hole, inefficient repair methods used, and further rehabilitation did not commence until after the second incident occurred six years later. When DOT expedited the construction plan, information was not disseminated to local media sources, elected officials, and community members. The disconnect between the city and state agencies, the elected officials, and the community is addressed in this thesis.

G. MAJOR ACCIDENT ON VICTORY BOULEVARD

Our final example of poorly coordinated post-event emergency collaboration was the lack of city agencies' and private companies' communication requiring street closure for two and a half days after an early morning car accident at closed a section of a major Staten Island thoroughfare. On September 7, 2015, at 2 a.m., a driver lost control of his

¹⁷⁹ Vincent Barone, "Sen. Gillibrand Pushes Measure For More Bridge Funding," *Staten Island Advance*, June 3, 2015, http://www.silive.com/news/index.ssf/2015/06/sen_gillibrand_pushes_measure.html.

¹⁸⁰ Vincent Barone, "Hole in Hylan Boulevard Overpass Prompted Emergency Closures," *Staten Island Advance*, June 11, 2015, http://www.silive.com/news/index.ssf/2015/06/hole_in_hylan_boulevard_overpa.html.

¹⁸¹ Virginia N. Sherry, "New Hole Opens in Hylan Boulevard Expressway Overpass," June 22, 2015, *Staten Island Advance*, http://www.silive.com/eastshore/index.ssf/2015/06/another_hole_in_hylan_boulevard.html.

vehicle, striking a tree. While the driver only suffered minor injuries, the chain reaction began with the impacted tree falling on overhead power lines, pulling them down along with multiple utility poles supporting those wires. Figures 26 and 27 show the extent of the damage.¹⁸²

Figure 26. Victory Boulevard Accident¹⁸³



Photo Credit: Anthony DePrimo

¹⁸² Paul Liotta, “Victory Boulevard Still Closed for Second Evening Commute,” *Staten Island Advance*, September 8, 2016, http://www.silive.com/news/index.ssf/2016/09/victory_blvd_still_closed_for.html.

¹⁸³ Source: Ibid.

Figure 27. Victory Boulevard Accident¹⁸⁴



Photo Credit: Anthony DePrimo

Residents complained to local media, resulting in reporters questioning agency response. After the new poles were installed, DOT referred questions regarding re-opening the street to the NYPD, who forwarded requests to Con Edison, the local electricity provider. The New York City Fire Department representatives present indicated the reason for closure was the need for Con Edison to hang new wires. The NYC Councilwoman in that district, Deborah Rose, stated, “It’s ridiculous that Victory Boulevard, a major thoroughfare, is closed to through traffic during weekday rush hours, and on the first day of school.”¹⁸⁵ Residents and elected officials were understandably outraged regarding the lack of communication regarding re-opening status.

¹⁸⁴ Source: Ibid.

¹⁸⁵ Ibid.

H. CONCLUSION

This chapter lists specific incidents collected from elected officials' reports, local media stories, and personal observation, making those local elected officials the repository of concerns of the taxpayers, who insist on a more transparent and accountable government. The events are organized by order of increasing necessity for communication. The first section details street widening, water runoff, and pedestrian safety; these incidents require communication between city agencies. The second grouping: Superstorm Sandy buyout and Gateway National Park, required collaboration with state and federal agencies, respectively. Finally, the Hylan Boulevard deterioration and Victory Boulevard accident also demonstrate failure in emergency event coordination. The NYC Mayor's Office of Operations coordinates pre-event collaboration and follow-up. NYC Emergency Management (NYC EM) is tasked with collaboration of resources in a post-emergency environment. The last two incidents reflect the need for coordination of city services in emergency incidents. A communication model for non-emergency incidents would greatly assist in emergency incidents as well. A dedicated Mayor's Office of Infrastructure and a system of pre-event, routine communication and monitoring, such as the NYPD's CompStat model, will ensure effective organization between agencies and that resources are spent wisely.

Chapter V details how CompStat works within the NYPD and how it could be applied to create the NYC Mayor's Office of Infrastructure.

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V. COMPSTAT

Chapter IV presented sample events of communication failures that resulted in wasted tax dollars and, in some cases, limited access to roadways for emergency response and everyday transportation. Chapter V analyzes the New York City Police Departments CompStat model as a possible solution; CompStat significantly reduced crime in NYC while encouraging communication-enhancing accountability and Chapter V also reviews models similar to CompStat from other police departments and disciplines. This thesis recommends that the mayor's office prioritize CI by creating the NYC Mayor's Office of Infrastructure, and that the Office of Infrastructure implement a CompStat model to ensure CI fixes, by building on the existing office of Operations Infrastructure theme. Adapting the NYPD's model of CompStat to CI improvement and protection will create a system of communication, accountability, and interagency collaboration.

A. OVERVIEW

Performance measurement enables officials to hold organizations accountable and to introduce consequences for performance. It helps citizens and customers judge the value that government creates for them. And it provides managers with the data they need to improve performance.¹⁸⁶

CompStat, short for comparative statistics, is a police management and accountability tool that began in the NYPD in 1994. Police Commissioner William Bratton spent time with the Boston Metro Police Department and the NYC Transit Police before being appointed by Mayor Rudolph Giuliani to head the largest police agency in the country, at a time of uncontrolled crime and decreasing quality of life.¹⁸⁷

At the time, New York City was ten years into the fight against the crack epidemic and needed a system of accountability to monitor and reduce crime. During

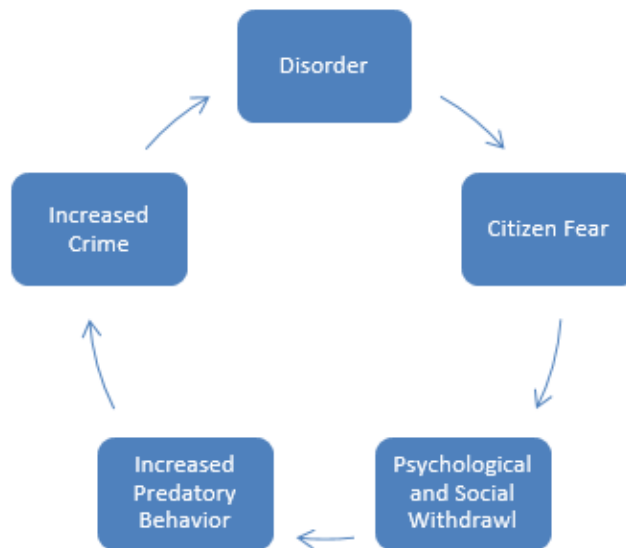
¹⁸⁶ David E. Osborne and Peter Plastrik, *The Reinventor's Fieldbook: Tools for Transforming Your Government* (Jossey-Bass San Francisco, CA, 2000).

¹⁸⁷ Bratton, William, and Peter Knobler. *The Turnaround: How America's Top Cop Reversed the Crime Epidemic*. New York: Random House, 2009.

those ten years, the homicide rate for African-American males age 14–24 had doubled, 60 percent of prisoners’ cases involved drug offenses, and the fetal mortality rate in inner cities had increased by over 20 percent.¹⁸⁸ Quality of life, in general, was deteriorating rapidly.

Violence typically begins as lower-level disorder and chaos. Commissioner Bratton associated Kelling’s and Wilson’s “broken windows” theory to lower-level quality of life crimes. “Broken windows” theorizes that, if lower-level violations are left alone, an increase in more serious crimes will occur.¹⁸⁹ The name comes from the belief that a broken window left in disrepair is a sign that property owners do not care, resulting in more broken windows and destruction.¹⁹⁰ Wesley Skogan, Northwestern University policing and disorder professor, identified the cycle shown in Figure 28.

Figure 28. Spiral of Decline¹⁹¹



¹⁸⁸ “Cocaine, Conspiracy Theories & the CIA in Central America,” Frontline, accessed July 31, 2016. <http://www.pbs.org/wgbh/pages/frontline/shows/drugs/special/cia.html>.

¹⁸⁹ James Q. Wilson and George L. Kelling, “The Police and Neighborhood Safety: Broken Windows,” *Atlantic Monthly* 127, no. 2 (1982).

¹⁹⁰ Ibid.

¹⁹¹ Source: George L. Kelling and Catherine M. Coles, *Fixing Broken Windows: Restoring Order and Reducing Crime in our Communities* (New York: Simon and Schuster, 1997).

This cycle demonstrates how the broken windows theory contributes to more lawless behavior as the cycle worsens. To disrupt the pattern, the NYPD needed a system to address the increased crime by tracing the cycle backward to citizen fear and disorder. The CompStat model monitored the aspects of the cycle and created accountability for those entrusted to disrupt it.

Commissioner Bratton and a team of dedicated advisors devised the CompStat system, in order to combat crime with accountability, based on four principles:

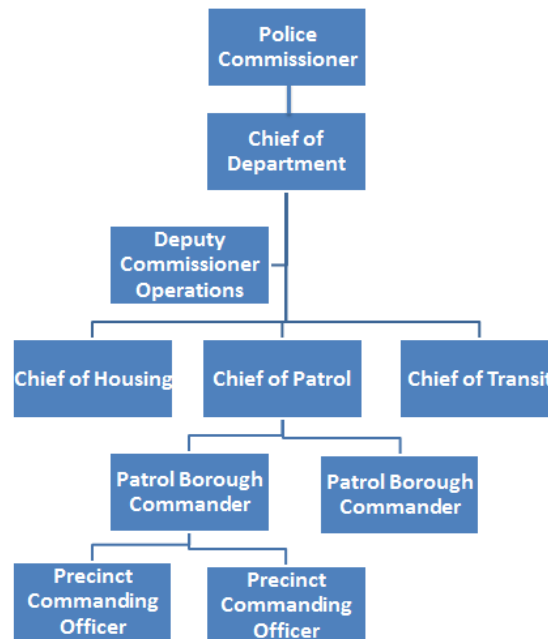
- Accurate and timely intelligence
- Effective tactics
- Rapid deployment
- Relentless follow-up and assessment¹⁹²

The principles and structure are addressed in the following section but due to the terminology used, it is important to discuss a sample of the New York City Police Department's structure as it relates to CompStat.

There are currently 77 precincts in New York City divided into five geographic boroughs and eight patrol boroughs. The police commissioner is a civilian title, appointed by the mayor. The chief of department is the highest-ranking uniformed member of the department. The deputy commissioner of operations is also a civilian rank who works directly for the chief of department and is tasked with overseeing CompStat. The NYPD is broken down into bureaus covering housing, transit, transportation, detectives, and patrol functions. The chief of patrol commands the eight patrol boroughs, each supervised by an assistant chief, titled borough commander. The borough commander oversees the precincts within his or her patrol borough. In Figure 29, the author outlines a sample of the hierarchical structure within the NYPD, depicting one patrol borough with two precincts as an example.

¹⁹² Raymond Dussault, "Jack Maple: Betting on Intelligence," *Government Technology* (1999).

Figure 29. NYPD Hierarchy



B. FOUR PRINCIPLES OF COMPSTAT

The four principles of CompStat depict the process of monitoring crime increase and fostering crime decrease. The descriptions come from the first Deputy Commissioner of Operations, Jack Maple's, writings, and this author's personal observations of over a decade of CompStat experience. In Chapter VI, this thesis demonstrates the use of CompStat and the four principles as a model of performance management for critical infrastructure (CI) through communication and accountability.

1. Accurate and Timely Intelligence

Accurate and timely intelligence is an essential first step to the CompStat process, which would also work well for a CI system.¹⁹³ A methodology must be in place to quickly track the criteria the director decides upon. In the case of the NYPD's CompStat model, the intelligence is the seven index crimes and quality-of-life violations. The focus is the analysis of computer-driven statistical data for each crime, including where it

¹⁹³ Jack Maple and Chris Mitchell, *The Crime Fighter: Putting the Bad Guys Out of Business* (New York: Broadway Books, 2010).

occurred, when, the method of commission, and pedigree descriptions of the victim(s) and the perpetrator. The FBI's Unified Crime Reporting Data dictates the categories of crime tracked: criminal homicide, forcible rape, robbery, aggravated assault, burglary, larceny/theft, motor vehicle theft. The first adjustment needed was the timeliness of reporting. The FBI required the information sent yearly, but this delay prevented immediate analysis. Commissioner Bratton and Deputy Commissioner of Operations Jack Maple invested in the necessary technological advances to ensure intelligence gathering and forwarding on a daily basis. The application of this principle to road and bridge repair is the collection of data on projects initiated by all New York City agencies. Each agency currently has computerized records, most using Geographic Information Systems (GIS) technologies to plot incidents or projects on a map. A compatible software design is required to allow all agencies to collate and communicate together, to avoid overlapping initiatives.

This thesis explores creating a CompStat Unit within the newly created NYC Deputy Mayor of Infrastructure's Office, focusing on communication and accountability, to monitor and improve NYC CI. That process begins with the collection of intelligence on the current state of CI.

2. Effective Tactics

The second principle of CompStat, effective tactics, uses the previously collected intelligence to determine what resources are needed and where, which would be an excellent asset toward improving CI. It is the function of the department to foster, enable, and oversee the collection of said intelligence, and, once that intelligence is amassed, the precinct commander analyzes it to determine deployment. The phrase "put cops on the dots" has been employed to summarize the crime-reduction strategies.¹⁹⁴ Once commanders locate and analyze the trouble spots, they decide what level of enforcement is needed. That commander monitors the activity generated and the decrease in incidents of crime. The monitoring of the process will be covered further in the follow-up section of the CompStat process. Thinking outside of the box is encouraged of the precinct

¹⁹⁴ Ibid.

commander and his/her subordinates. A lack of resources, such as personnel or equipment, can impede progress, but a plethora of such resources is not necessarily the answer. Intelligently analyzed deployments are the backbone of the CompStat strategy.

Before CompStat, the NYPD was a more reactive agency; responding to complaints of crimes was part of the increase in lawlessness in the 1980s and '90s. Currently, NYC agencies tasked with CI are reactive as well. This thesis recommends a communication system to ensure proactive collaboration. The tactics employed in CompStat include addressing emerging issues as they arise and using multi-faceted proactive approaches to address them. The application of this principle to bridge and road repair includes prioritization of projects and a study of materials used to ensure effectiveness. Similar to the change in policing methods, this approach removes the reactive function of repair and strives towards proactive monitoring and repair.

3. Rapid Deployment

The third principle of CompStat, rapid deployment, prevented incidents in the NYPD's model—decreasing crime. Deploying city agencies responsible for CI, correctly, and in collaboration, will likely decrease incidents of road deterioration, traffic, and emergencies. In policing, using the accurate intelligence and the correct enforcement-strategies personnel can be allocated to areas of events. Rapid deployment is applicable in the reactive necessities of policing to prevent future incidents or retaliatory action.

In the proactive aspect, rapid deployment is used to gather intelligence and circumvent activities that may lead to criminal activity. Deployment may mean attendance at community meetings to disseminate crime prevention materials or physical changes, such as lighting or security facilities. The rapid deployment is an internal strategy, also. Monitoring personnel issues, disciplinary action against officers, overtime usage, sick time usage, and other NYPD programs creates a better-rounded agency.

In the model applicable to CI, the need is for prioritization as well as rapid deployment. City agencies have limited resources and money. Therefore, projects and initiatives need to be prioritized to ensure issues are tended to before they become larger and require more money and resources.

4. Relentless Follow-up and Assessment

Relentless follow-up and assessment is the most important aspect of the CompStat process or any performance-measurement related strategy; as such, it is also the most important aspect of implementing the CompStat strategy into critical infrastructure improvement. The follow-up phase is the recapitulation, which focuses on accountability. As the first Deputy Commissioner of Operations, Jack Maple, stated, “Nobody ever got in trouble because crime numbers on their watch went up...Trouble arose only if the commanders didn’t know why the numbers were up or didn’t have a plan to address the problems.”¹⁹⁵ This philosophy increases the attentiveness of precinct commanders. A quantitative analysis is the easiest way to track the outcome of CompStat, decreased criminal activity and increased police activity; summonses and arrests. A qualitative analysis is also useful. Did the plan work? Why or why not? What aspects of the plan will be used in the future plan or the next plan for the next incident? Complaints from the community can also be tracked, monitored, and followed-up on to determine success. The citizens’ perception of order versus lawlessness is a guiding factor to the success of the precinct or the police as a whole. In the model recommended in this thesis, the citizens’ perception of safe CI leads to reassurance in government.

These four principles, as simple as they seem, revolutionized the way police work was conducted in New York City, followed by a majority of the country, then disciplines outside of law enforcement, by collecting intelligence, using better tactics, deploying the right resources to the right locations, and following up on performance. This thesis uses the four principles to recommend a methodology for applying these principles to the subject of critical infrastructure improvement focusing on bridge and roadway repair in New York City.

C. MEETING

Designing a potential NYC Deputy Mayor of Infrastructure CompStat Unit requires understanding the meeting format and forum to incorporate and display the four principles correctly. The CompStat meeting itself is only a small part of the CompStat

¹⁹⁵ Ibid.

philosophy. CompStat is not one day or one meeting. CompStat is daily and starts the second you leave the CompStat meeting. The meeting is the culmination of the plans you have put in place and the accountability for their successes or failures. It is also the podium to discuss future programs and deployments.

Weekly CompStat meetings are the means by which agency leaders can analyze and evaluate the overall trends in all key crime indicators and risk management issues. They provide the opportunity for ongoing follow-up and assessment and, just as important, serve to reaffirm responsibility and ownership of crime problems within a command's purview as well as those that cross jurisdictional boundaries.¹⁹⁶

The meeting, sometimes called "the show," is the culmination of all monitoring activities and the podium is the sounding board for the commanders to present their knowledge and leadership, their commitment to improvement and safety.

The five geographic boroughs of New York City—Manhattan, Brooklyn, Queens, Bronx, and Staten Island—are divided into eight Patrol Boroughs by the NYPD. The NYPD separates Manhattan, Brooklyn, and Queens into a North and South sections to better manage the size, geography, and number of precincts. A precinct is a geographic area supervised by a Commanding Officer and overseen by a Patrol Borough Commander. Except for Staten Island, Patrol Boroughs have approximately eight to thirteen precincts contained therein.

Weekly, a different Patrol Borough will be called to CompStat. The meeting is always Thursday from 8 am until 11 am in Police Headquarters. On Monday, a borough is selected based on the previous week's crimes or major incidents and a list of cases is sent out through the entire department. Those cases are complaints of crimes and contain all the documentation done by the responsible investigative unit. At the meeting, the upper echelon of the NYPD sits at the front dais, the Chief of Department, the Deputy Commissioner of Operations and the Chiefs of all Bureaus, namely Patrol, Housing, Transit, Detectives, Organized Crime, Community Affairs, and Training. On the arms of the horseshoe-shaped table sit the Borough Commanders and their staff as well as the

¹⁹⁶ Godown, "The CompStat Process," 36–38.

Precinct Commanders and his/her respective staff. Members of other NYPD units that may have a stake in the cases and precincts occupy the rest of the room. Examples of these include Robbery Squads, Gang Division personnel, Financial Crimes, Gun Suppression units, and my own Special Victims Division. The reason to have these sub-units present is to address overlapping issues or perpetrators. Non-NYPD units such as the District Attorney's Office, Department of Parole, and Department of Probation attend to answer any questions relating to their particular expertise.

The Chief of Department calls an average of three precincts to present at the podium per CompStat; this system can be duplicated into CI by including the agencies responsible for CI improvements into the meeting, but only having specific agencies present their progress. The Precinct Commanders, their subordinates, and sub-units provide an overview of their precincts and answer specific questions posed by the speaker at the dais. This referenced design and format is that which the NYPD employs, research has shown that different departments and disciplines perform their respective stat meetings differently.

In seeking to replicate the NYPD's CompStat model, many agencies have accepted invitations to attend the meeting in person, demonstrating their recognition of its success. A survey completed in 1999 "revealed that a third of the nation's 515 largest police departments had implemented a CompStat-like programme and 20% were planning to do so by 2001. The same survey found that about 70% of police departments with CompStat programmes reported attending an NYPD CompStat meeting."¹⁹⁷ Some research indicates the failure of agencies to adopt a successful CompStat model is due to reliance on the meeting without the full-time monitoring of conditions and daily follow-up

Chapter VI discusses the development of the CompStat Unit for CI regarding the location, division, and subdivision of various city agencies that might be involved in the process. Figure 30 shows the physical positioning of the CompStat Dais. The Chief of

¹⁹⁷ John A. Eterno and Eli B. Silverman, "The New York City Police Department's Compstat: Dream or Nightmare?" *International Journal of Police Science & Management* 8, no. 3 (2006): 218–231.

Department and DCO sit at the center of the dais and share responsibilities of questioning attendees.

Figure 30. CompStat Dais Overview¹⁹⁸



Figures 31 and 32 depict the size of the CompStat room and the positioning of members for maximum visibility. The Commanding Officer and precinct's management team present to the upper echelon from the CompStat podium.¹⁹⁹ These figures serve as a display of layout and, in the model recommended by this thesis, could be used as a

¹⁹⁸ Adapted from William Bratton, "William Bratton's Twitter Page," Twitter. accessed November 11, 2016, <https://mobile.twitter.com/CommissBratton/status/720960865911062528>.

¹⁹⁹ Adapted from "I-Team: NYPD Provides Unprecedented Look at Compstat," NBC News, April 15, 2016, <http://www.nbcnewyork.com/news/local/Compstat-New-York-NYPD-Police-Tour-375761141.html>.

guide. It is anticipated that fewer members would be present in the NYC Mayor's Office of Infrastructure CompStat meeting.

Figure 31. CompStat Dais²⁰⁰



Figure 32. CompStat Podium²⁰¹



²⁰⁰ Adapted from NBC News, "I-Team: NYPD Provides Unprecedented Look at Compstat," April 15, 2016, <http://www.nbcnewyork.com/news/local/Compstat-New-York-NYPD-Police-Tour-375761141.html>.

²⁰¹ Adapted from Ibid.

Figures 31 and 32 depict the size, structure, and set up of the NYPD's CompStat meeting room. The layout is similar to other agencies' CompStat models and creates an atmosphere necessary to the function.

D. COSTS, TECHNOLOGY, AND STAFFING

Developing the NYC Deputy Mayor of Infrastructure's CompStat Unit would require office space, a meeting space, computers and software, and the personnel to effectively apply the four CompStat principles to CI. City agencies currently monitor their respective projects but in a silo-driven system that does not allow for collaboration with other agencies or private companies. Chapter VI addresses the design of the office and meeting room as duplicated from the NYPD's Deputy Commissioner of Operations' (DCO) office.

The DCO moderates CompStat, making him/her fourth in ranking structure and equal to the Bureau Chiefs who sit at his/her side at CompStat meetings. All rank under the Chief of Department whose purview covers the entire department. An NYPD Inspector supervises the Office of the DCO; the Inspector's position is essential to the operation of the office. Precinct commanders are usually deputy inspectors or captains; therefore, no precinct commander outranks the Inspector in the DCO's Office

The primary function of the members of the DCO's office is to analyze the 100,000-plus index crimes that occur in NYC yearly and prepare reports to the Chief of Department and the DCO. These reports include investigative work, historical breakdowns of the victim, perpetrator, and location.²⁰² Their work also involves other clerical and internal issues of managing the NYPD, such as complaints against officers, sick leave, overtime, and quality of life Complaints. The yearly salary for the 40 members of the DCO's office is approximately \$4 million²⁰³—a staggering amount, yet their job function is and will be different from the citywide model proposed. The respective city agencies already have representatives tasked with tracking initiatives and

²⁰² "Crime Statistics," New York City, accessed September 10, 2016, http://www.nyc.gov/html/nypd/downloads/pdf/crime_statistics/cs-en-us-city.pdf.

²⁰³ Personal communication with author.

projects and also support the computer terminals and databases required by this recommendation.

This thesis recommends the creation of a NYC Deputy Mayor of Infrastructure with a CompStat component; to do so, the NYPD's CompStat model and those adapted by other agencies and disciplines must be studied to design the space, format, and methodology. Next, this thesis describes other CompStat-style performance management models and the grouping of all models into a system of accountability.

E. OTHER USES OF COMPSTAT

This thesis recommends development of an NYC Deputy Mayor of Infrastructure CompStat Unit based on the NYPD's CompStat model as described in the previous section. This section details other applicable uses of the CompStat model by agencies in New York City. In 1984, the New York City Department of Parks and Recreation began the Parks Inspection Program (PIP) to monitor its performance internally. PIP started out as a review conducted three times a year, but, in 1995, it was changed to a bi-weekly randomly selected inspection location and a follow-up meeting to the meeting before.²⁰⁴ NYC Parks changed the meeting name in 1997 to ParkStat, and, in one meeting, a park manager told the executive moderating the meeting that an issue with his park was due to the Department of Transportation (DOT) not promptly repairing a roadway under his control but within a park. The moderator's follow-up question was, "How can we put more pressure on DOT—what can be done at a higher level?"²⁰⁵ That moderator saw the potential of incorporating multiple agencies into one meeting in an attempt to create positive change.

Another adaptation of the CompStat model into other NYC agencies is HealthStat, a program that began in New York City in 2000 to ensure all eligible New Yorkers, especially children, are enrolled in state and federal health programs. The program incorporated different NYC agencies: the Department of Health, the Housing Authority, the Human Resource Administration, the Board of Education, and others

²⁰⁴ O'Connell, *Using Performance Data for Accountability*, 179–223.

²⁰⁵ *Ibid.*, 199.

reporting to the Deputy Mayor of Health Care Access. An unlikely partner agency that provided the most information was the Department of Corrections. Daily, thousands of New Yorkers enter Riker's Island Correctional Facility, both as defendants and family members visiting incarcerated members.²⁰⁶ This system allowed access to those most vulnerable to lacking health care coverage.²⁰⁷ Research shows that HealthStat is the only multi-agency meeting to be held in New York City with a common goal, making it an ideal stat to look to for creation of the Mayor's Office of Infrastructure.

Baltimore, Maryland, has succeeded with the only documented multi-agency PerformanceStat program. Soon after the NYPD's CompStat was introduced, the Baltimore mayor tapped Jack Maple, the architect of the NYPD's CompStat, to design a citywide program for Baltimore called Citistat. In addition to crime reduction, Baltimore also experienced decreased overtime in city agencies and cleaner public parks.²⁰⁸ In documenting the results, the program has also yielded qualitative results such as expedited movement on problems and better interagency collaboration.²⁰⁹

Adapting CompStat principles to other agencies or cities has proven to be successful. ParkStat continues today, and Citistat has saved money by monitoring different aspects of city government in one forum. HealthStat, as a temporary system, coordinated agencies under the direction of mayor's office. Combining interconnected disciplines of CI into one mayor's office can yield the same results and improvements.

F. PERFORMANCESTAT MODELS

This thesis recommends that NYC develop a CI CompStat using methodology developed by performance management researcher Robert Behn. Behn studied various CompStat programs from different cities and disciplines, combining them into a performance management system called PerformanceStat.²¹⁰ His research presents a

²⁰⁶ Ibid.

²⁰⁷ O'Connell, *Using Performance Data for Accountability*, 200–201.

²⁰⁸ Ibid., 207–208.

²⁰⁹ Ibid.

²¹⁰ Behn, "Designing PerformanceStat," 207.

format to be followed to ensure a successful CompStat-type meeting. The NYPD was the first organization to establish CompStat in 1994, with many organizations and disciplines following. All models of PerformanceStat should be studied to ensure success and avoid failures in developing an office for CI CompStat.

A jurisdiction or agency is employing a PerformanceStat performance strategy if it holds an ongoing series of *regular, frequent, periodic, integrated meetings* during which the chief executive and/or the principal members of the chief executive's leadership team plus the individual director (and the top managers) of different subunits *use data* to analyze the unit's past *performance*, to *follow up* on previous decisions and commitments to improve *performance*, to establish its next *performance* objectives, and to examine the effectiveness of its overall *performance* strategies.²¹¹

Behn acknowledges that the most important aspects of CompStat meetings are “two key pieces of infrastructure: (a) some technology to help collect, analyze, and display the data and (b) a room in which to hold the periodic meetings,”²¹² but also addresses the authority and full-time position of the moderator and the dedication of all attendees.

For stat (CompStat, PerformanceStat, or similar model) success, primarily, those attending the meeting or adhering to the process must understand that the signals communicated are coming from the highest levels of the organization or the highest levels of city government in those stats that involve multiple agencies. “No precinct commander doubted that Anemone and Maple had Bratton's full backing. In Baltimore, no department head doubted that Enright and Gallagher spoke for the mayor.”²¹³ The highest rank present at the CompStat meeting must communicate the same authority and purpose as the absent higher ranks, as such, in the model recommended by this thesis, the mayor need not regularly attend, but all attendees must know that the moderator is speaking with his/her authority.

Secondly, Behn's research shows that agencies with the best rates of success staff their PerformanceStat office full-time. In the NYPD's CompStat program, the Deputy

²¹¹ Ibid.

²¹² Ibid., 206, 235.

²¹³ Ibid., 219.

Commissioner of Operations (DCO) is a full-time employee whose only job function is CompStat. The NYC Deputy Mayor of Infrastructure CompStat Unit requires a member permanently assigned and whose hierarchical status is higher than or equal to the agency commissioners.

A third key aspect of the Behn-related research is ensuring the stamina to keep the program progressing even though results may not be immediate. In the agencies and locations studied, Palmer, a doctoral candidate at UNC–Chapel Hill noted there was an average of three years before significant progress can be noted.²¹⁴ In a recent CompStat meeting, the DCO stated that the stamina to begin and continue a CompStat program is critical to success and the inability to continue that stamina is most often the reason for program failure.

To maintain a successful CompStat meeting, a respectful, interactive back and forth between the Deputy Commissioner of Operations and the subordinate member presenting is necessary. Following this model, the moderator of the NYC Deputy Mayor of Infrastructure CompStat Unit and the presenter must adhere to the four principles while discussing past incidents and future deployments. Behn also states, “the meeting can evolve into a game. The leadership plays gotcha, while the subunit participants respond by attempting to score debating points, devoting their time to anticipating and rebutting the gotcha questions. In the gotcha game, no one is attempting to actually improve performance”²¹⁵ Rather than acting as if CI is a game, presenters must believe in the methodology to enable true improvements and the questioning members at the dais must maintain professional decorum to promote true accountability.

To promote city government transparency, some researchers have studied the ability of PerformanceStat to function open to public viewing, without limiting conversation. In law enforcement–related PerformanceStats, some topics and initiatives are ongoing and open investigations are a concern. Many public managers are reluctant to engage in open conversation in public. As one manager noted, “If we are having a

²¹⁴ Jonathan Palmer, “Municipal PerformanceStat: How Is Success Defined? What Factors Contribute to Success?” (Ph.D. diss., UNC-Chapel Hill, 2010).

²¹⁵ Behn, “Designing PerformanceStat,” 207.

conversation about the police department, the police chief would be willing to admit his department dropped the ball, but that would never happen with the press in the room.”²¹⁶ Unlike law enforcement, issues presented at PerformanceStats, CompStat, or a CompStat for CI are meant for public viewing.

Behn summarizes the creation of a PerformanceStat system as follows:

To make an intelligent use of the PerformanceStat strategy, the leaders of the adopting organization need to (a) specify the performance purpose they are trying to achieve; (b) decide what performance data they will collect and analyze; (c) build a small staff to analyze these data; (d) assemble the necessary infrastructure; (e) determine how they will conduct the meetings; (f) build the requisite operational capacity; (g) create an explicit mechanism to follow up on the problems identified, solutions proposed, and decisions made at these meetings; and (h) think through carefully how they adapt the features and principles of other versions of PerformanceStat to their own purpose and situation.²¹⁷

Following the format of PerformanceStat described in this chapter, the NYC Deputy Mayor of Infrastructure CompStat will moderate, promote communication between agencies, and create greater improvement in CI. Chapter VI discusses the particular structure of the office.

G. CRITIQUES OF COMPSTAT MODELS

In adapting the CompStat principles to CI improvement, it is important to note that the philosophy is not without critiques of its successes and methodology. The preceding sections point to the successes of the program and later chapters describe how to implement the system in the world of CI protection; however, criticisms are divided into three categories: inflated numbers and unconstitutional practices, factors causing lower crime rates, and the costs to the morale of the organization. As retired NYPD captain Phil Eterno and CompStat researcher Eli Silverman wrote, “the weaknesses of

²¹⁶ Palmer, “Municipal PerformanceStat.”

²¹⁷ Behn, “Designing PerformanceStat,” 207.

CompStat are less recognised: due process considerations, community relations, leadership issues, [and] inadequate problem solving.”²¹⁸

The questioning of commanders regarding crime increase and its relation to activity levels by police officers is alleged to have caused commanders to demand more activity.²¹⁹ The demand was sometimes misconstrued as a “by any means necessary approach” leading to unconstitutional stops. Others attribute CompStat demands to more aggressive tactics, and the increase in Stop and Frisk incidents to document said stop as proof of activity for crime conditions.²²⁰ W. K. Rashbaum wrote an article for the *New York Times* in 1996 that cited, “Civilian complaints against police for allegedly illegal searches skyrocketed by 135% in the first two years....Illegal vehicle searches jumped...108%...[and] allegations of illegal apartment searches shot up 179%.”²²¹ Eterno and Silverman added, “Thus, as crime decreased, civilian complaints for abuse of authority increased. This negative relationship is certainly glaring but only one of several measures indicating a problem.”²²²

The second critique questions whether CompStat was truly the reason for the massive crime reductions cited. Some research points to other reasons for declining crime rates:

- Demographic change—This hypothesis states that the offenders of serious crimes aged out of the demographic that would commit such crimes.²²³

²¹⁸ Eterno and Silverman, *The New York City Police Department's Compstat: Dream or Nightmare?* 218–231.

²¹⁹ Oliver K. Roeder et al., “What Caused the Crime Decline?” (Research Paper, no. 15-28, Columbia Business School, 2015), 72.

²²⁰ The Fourth Amendment requires that the police have a reasonable suspicion that a crime has been, is being, or is about to be committed before **stopping** a suspect. If the police reasonably suspect the person is armed and dangerous, they may conduct a **frisk**, a quick pat-down of the person’s outer clothing. As per NYPD protocol, these stops would be recorded on a Department form; UF-250 Stop and Frisk Report.

²²¹ W. Rashbaum, “Complaints Against Cops Surge 135%,” *New York Daily News* 22 (1996).

²²² Eterno and Silverman, *The New York City Police Department's Compstat: Dream or Nightmare?* 218–231.

²²³ James Alan Fox, “Demographics and U.S. Homicide.” *The Crime Drop in America* (2000): 288–317.

- More police—Due to economic prosperity larger cities had more money to expand police departments, some, such as New York City, supplemented by federal money.²²⁴
- Changing drug markets—Outdoor drug markets relocated to indoor locations thereby eliminating the ability to attack rival drug dealers.²²⁵ One would argue that the technological advancements of cellular phones and social media also led to greater declines.
- Increased abortion—Due to the increased rates of abortion in the early to mid-1970s, fewer children were born into at-risk homes, thus there were fewer children growing up into an at-risk household and susceptible to gang and drug activity.²²⁶

Social scientists insisting on varying reasons for crime rates decreasing diminish the involvement of the NYPD in the process. Arrest activity increased, structured analyzed placement of personnel occurred, and crime rates dropped. These factors do not relate to CI or Homeland Security, but serve as reminders that contrary research always exists.

In adapting the CompStat principles to CI and creating the NYC Deputy Mayor of Infrastructure, an agency submitting fraudulent numbers and reports is a concern, but a larger concern is the morale of the agency and the organizational behavior of adapting to sweeping change. Research, interviews, and surveys all indicate that the negative attributes of CompStat induced fear, alienation, and misdirection to precinct commanders. Studies have shown that poor performance at a CompStat meeting or poor indicators in CompStat categories has resulted in “punishment,” yet good performances and indicators rarely generate a reward.²²⁷

Relating back to Behn’s PerformanceStat, he found that follow-up must be relentless as the fourth principle states, but should not be hostile, stating “follow-up is

²²⁴ Thomas B. Marvell and Carlisle E. Moody, “Specification problems, police levels, and crime rates.” *Criminology* 34, no. 4 (1996): 609–646.

²²⁵ Steven D. Levitt, “Understanding Why Crime Fell in the 1990s: Four Factors That Explain the Decline and Six That Do Not.” *The Journal of Economic Perspectives* 18, no. 1 (2004): 163–190.

²²⁶ John Donohue and Steven Levitt. *The Impact of Legalized Abortion on Crime* (Working Paper no. 8004). *Quarterly Journal on Crime*, 2000.

²²⁷ *Ibid.*, 223.

absolutely necessary, and it ought to be persistent.”²²⁸ To document the loss of morale, Eterno and Silverman interviewed captains who presented at CompStat and stated that they “feared embarrassment during their presentations...high-level Executives would berate them in public if their crime numbers were not decreasing...commanding officers feared presenting at CompStat meetings and would do almost anything to escape the embarrassment...fear was observed as a central aspect of CompStat in New York City.”²²⁹ To create improvements, implementing CompStat in CI must be professional and not induce fear. Based on personal observations, the mood in a CompStat meeting fluctuates based on spectators present. Holding the meeting publicly or having media presence may force the professional demeanor to be maintained

Research done as well as personal observations indicate that the strong hierarchal structure of the NYPD leads to the successes of CompStat. There is no doubt who is in command of the proceeding and the department. As Eterno and Silverman detailed, embarrassment and fear are motivators to ensure better performance on subsequent visits, and when directed to perform tasks or report back successes and failures, there is not the ability to say no or just fail to do so. Weisburd, a criminologist, adds, “This supervisory system is strongly hierarchical and essentially negative, relying primarily on sanctions for noncompliance with police rules and regulations,”²³⁰ and that CompStat is an “effort to maintain and reinforce the ‘bureaucratic ‘or ‘paramilitary’ model of police organization.”²³¹ Weisburd’s work does not reflect the fact that a strong supervisory system, such as CompStat, also increases accountability.

Overall, as the rates of crime reduction overshadow the negative aspects of CompStat, promoting safety in CI through improved communication, collaboration, and accountability will enable the success of the Deputy Mayor of Infrastructure’s office.

²²⁸ Behn, “Designing PerformanceStat,” 206–235.

²²⁹ Eterno and Silverman, *The New York City Police Department's Compstat: Dream or Nightmare?* 218–231.

²³⁰ David Weisburd et al., “Reforming to Preserve: Compstat and Strategic Problem Solving in American Policing,” *Criminology & Public Policy* 2, no. 3 (2003), 421–456.

²³¹ Ibid.

H. CONCLUSION

This chapter provided an overview of the origination of CompStat: its principles, format, national models, and critiques. As observed in the research, the NYPD began the CompStat model; research and personal observations demonstrate that the NYPD is still at the forefront of the CompStat dynamic, adapting the design as times change. Eterno and Silverman look to the future of CompStat and determine that “the NYPD needs to acknowledge and learn from weaknesses in the process and begin to develop models of policing that will take into account lessons learned.”²³²

Basic models of the stat process should be adhered to, but varying the structure allows applicability to other agencies and disciplines. Eterno and Silverman close their paper by citing the positive aspects of efficiency, command structure, expectations of workers, and reduction of bias. Also included are the negative aspects of depriving employees of having a decision-making voice, the concealment of mistakes, discouraging loyalty, and alienation.²³³ The stat process as described earlier is a model of planning and accountability to allocate resources efficiently. It cannot be viewed as a process to take a poorly supervised agency or disconnected agencies and force better results.

In 1998, First Deputy Mayor Joseph Lhota stated, “It [the stat process] can be used in any area of government. The fact that it was developed in the public safety area does not mean that it has to stay there.”²³⁴ Following this sentiment, the creation of the Mayor’s Office of Infrastructure with a CompStat component can have the same degree of improvement as CompStat had in the NYPD. Chapter VI discusses the methodology of creating the Mayor’s Office of Infrastructure and designing a CompStat model within.

²³² Eterno and Silverman, *The New York City Police Department's Compstat*, 229.

²³³ Ibid., 227.

²³⁴ O’Connell, *Using Performance Data for Accountability*, 179–223.

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IV. ANALYSIS AND RECOMMENDATIONS

Another definition of accountability is: the act of holding the subordinate liable for performing those activities for which he or she has been delegated the necessary authority and responsibility.

—Louis Eugene Boone, James W. Baird,
David Lee Kurtz, and Israel B. Markowitz²³⁵

Accountability and communication are two crucial aspects of the CompStat process, both also particularly key to solve the needs surrounding NYC critical infrastructure (NYC CI). Chapter V discussed the NYPD's CompStat program, including its successes and flaws. Chapter VI develops the strategy of implementing the CompStat principles into NYC CI plans to increase accountability, communication, and prioritization. The proposed system prioritizes cost-effective improvements and homeland security, specifically CI, by enabling quicker emergency response and ability to evacuate if necessary.

A. INCREASED ACCOUNTABILITY FOR NYC CI

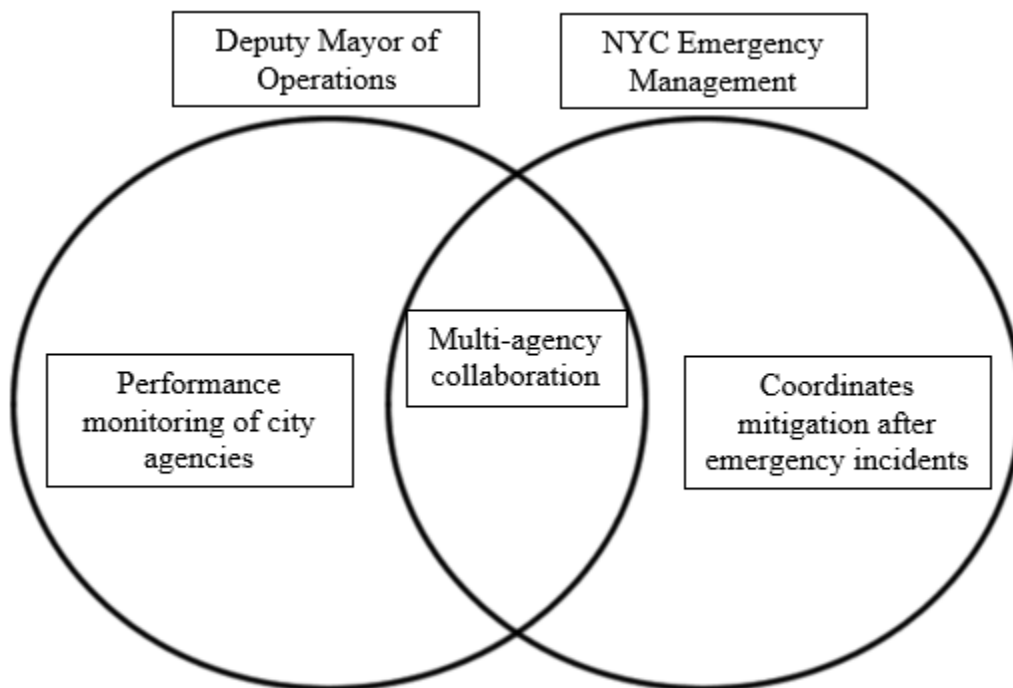
Currently, monitoring and assessing city agencies occurs in the NYC Mayor's Office of Operations; coordination of agencies for emergency incident response is overseen by New York City Emergency Management (NYC EM). This thesis recommends moving CI concerns from the Mayor's Office of Operations into a newly created Deputy Mayor of Infrastructure (DMI) Office and creating a CompStat Unit within that office to collaborate with NYC EM to measure the performance of agencies and ensure communication.

The Mayor's Office of Operations and New York City Emergency Management currently have overlapping responsibilities. Although both agencies oversee collaboration in multi-agency response, as depicted in Figure 33, Emergency Management is better at

²³⁵ Boone, Louis Eugene, James W. Baird, David Lee Kurtz, and Israel B. Markowitz. *Principles of Management* (New York: Random House, 1984).

multi-agency coordination post-event, than the Mayor's Office of Operations has been pre-event. This thesis recommends creation of the DMI to enable true collaboration, communication, and accountability.

Figure 33. Overlapping Mission Statements



The current structure, as shown in Figure 33, causes duplicate work and important issues to not be addressed in a timely manner due to communication and accountability failures. This thesis recommends developing an accountability model to improve CI.

The structure of New York City government begins with the mayor, then the first deputy mayor, and then additional deputy mayors who are on par with commissioners of city agencies. Under this plan, the city would create a position of the deputy mayor of critical infrastructure. Creating a deputy mayor of critical infrastructure is not just creating more and bigger government. The NYC mayor has offices to combat domestic violence, for housing and economic development, and health and human services; therefore, if a system is failing, it needs to be brought into the forefront to be closely

monitored. The structure proposed follows the NYPD model where the person, or office, directing the CompStat process has higher authority than those presenting for their respective agency, increasing accountability.

The current NYC Mayor's Office of Operations, headed by a director, "works to make a government of over 40 agencies and 300,000 employees more effective, efficient, and coordinated in carrying out its day-to-day business,"²³⁶ and also "monitors the performance of all City agencies, holding each agency accountable for providing high quality services and making data about the City's performance readily available to the public."²³⁷ Information retrieved from their website reports increasing or decreasing performance in numerous indicators per agency; the NYC Mayor's Office of Operations reports this information via the Citywide Performance Reporting (CPR) tool.²³⁸ The CPR tool combines city agencies into eight citywide themes, including public safety, legal affairs, education, and infrastructure. The infrastructure theme combines reports on city agencies tasked with infrastructure but fails to define collaboration, coordination, or accountability and also fails to encourage participation of private companies.

The Mayor's Office of Operations website details how agency information is collected but does not explain any collaborative efforts. The Performance Management Team "monitors and reports on the performance of all City agencies, holding each agency accountable for providing high quality services," by maintaining the Citywide Performance Reporting (CPR) tool, a searchable online database presenting key performance measures from 44 city agencies.²³⁹ The Performance Management Team also issues the bi-annual Mayor's Management Report. The first report, issued early in the fiscal year, defines the direction the city intends to go, while the second, issued after the fiscal year ended, gives a recap of progress.

²³⁶ "Mission," NYC Mayor's Office of Operations, retrieved October 15, 2016, <http://www1.nyc.gov/site/operations/about/about.page>.

²³⁷ Ibid.

²³⁸ "CPR: Agency Performance Reporting," New York City Mayor's Office, retrieved October 15, 2016, <http://www.nyc.gov/html/ops/cpr/html/home/home.shtml>.

²³⁹ Ibid.

NYC Emergency Management, headed by a commissioner, coordinates mitigation efforts after emergency events. The agency has different sections to handle various functions of city government and different categories of emergency. These divisions form the structure for collaboration in pre-event planning discussed in this thesis. New York City's Emergency Management began as the New York office of the federal Office of Civil Defense in 1941.²⁴⁰ In 1950, it became a New York City agency and has developed under many incarnations since then, most notably as a subunit of the NYPD in 1975 and the Mayor's Office of Emergency Management (OEM) in 1996 by Mayor Rudolph Giuliani. Under current Mayor Bill DeBlasio, NYC OEM has been renamed New York City Emergency Management (NYC EM) as a rebranding to increase public awareness of the organization and get the public's assistance in coordination and preparedness.²⁴¹

Similar rebranding of city agencies, like creating Mayor's Office of Infrastructure, could improve CI. The NYC EM mission statement explains that the agency "plans and prepares for emergencies, educates the public about preparedness, coordinates emergency response and recovery, and collects and disseminates emergency information."²⁴² The author would be remiss in ignoring that, while the agency description and presentations by the NYC EM commissioner and chief of staff stresses the term *emergency*, the type of multi-agency communication recommended within does not currently fall under their purview, therefore creating the Deputy Mayor of Infrastructure in collaboration with NYC EM would enhance the accountability of agencies and companies in the infrastructure discipline.

NYC Emergency Management is divided into nine different divisions covering post-event scenarios, each division combines interconnected agencies. This thesis focuses on the Planning and Preparedness Division and the Transportation and Infrastructure Unit

²⁴⁰ "Agency History," New York City Emergency Management, accessed September 6, 2016, http://www1.nyc.gov/assets/em/downloads/pdf/agency_history.pdf.

²⁴¹ Ibid.

²⁴² "Overview," New York City Emergency Management, accessed September 6, 2016, http://www1.nyc.gov/assets/em/downloads/pdf/agency_history.pdf.

housed therein.²⁴³ The Transportation Unit “strengthens the resiliency of New York City’s massive power, telecommunications, water, and transportation infrastructure during disasters through response, recovery, and mitigation planning.”²⁴⁴ Under the plan proposed in this thesis, when collaborating with the Deputy Mayor’s Office of Infrastructure, the phrase “during disasters” can be removed revealing a section of the agency concerning itself with “strengthening the resiliency of New York City’s massive power, telecommunications, water, and transportation infrastructure through response, recovery, and mitigation planning.”

New York City Emergency Management also developed emergency support functions (ESF) to be commensurate with FEMA. FEMA’s ESF details different functions, such as transportation, communications, and firefighting, describing the types of work and responses that fall into those categories. NYC EM developed a listing of city agencies, state agencies, and private corporations that fall under their purview, as subject matter groups. These groups control, organize and regulate necessary functions to help continue normal basic life in and recovery from emergency incidents. Examples of these are the Health & Medical ESF, Public Safety ESF, Transportation ESF, and Infrastructure ESF.

B. INCREASED COMMUNICATION FOR NYC CI

The description of NYC EM indicates the functionality of the ESF collaboration in a post-event scenario, such as grouping together interconnected agencies in the CI discipline. Developing a performance management operation within the NYC Deputy Mayor’s Office of Infrastructure collaboration with NYC EM would bring together the interests of the agencies represented in this thesis. NYC EM’s Transportation ESF covers rail and bus transit, NYC Department of Transportation, NYS Department of Transportation, Taxi Commission, and representatives from areas outside of New York City. The NYC EM Infrastructure ESF covers the Department of Design and

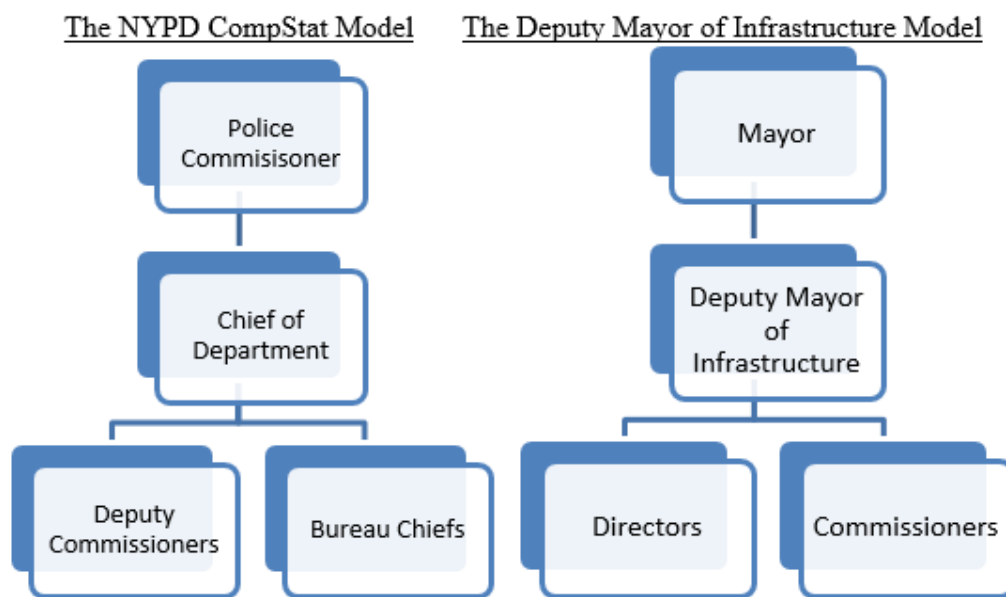
²⁴³ “Divisions and Units,” New York City Emergency Management, accessed September 6, 2016, <http://www1.nyc.gov/site/em/about/divisions-units.page>.

²⁴⁴ Ibid.

Construction, Department of Environmental Protection, Department of Parks, and similar agencies from other jurisdictions. These ESFs open jointly or as single units as necessary during a post-incident joint operation, and form the model for a CompStat meeting when combined with the Mayor's Office of Operations Infrastructure Theme in the Deputy Mayor of Infrastructure Office (DMI).

Forming a CompStat analysis section within the Deputy Mayor of Infrastructure Office and working with NYC EM enables communication, monitoring, and accountability. The Deputy Mayor of Infrastructure could coordinate the CompStat processes of setting up the technology, meeting space, and scheduling. A rank structure similar to the NYPD enables oversight, maintains accountability, and provides a hierarchical system to ensure compliance with mayoral orders. The Deputy Mayor of Infrastructure can examine CompStat for its strengths and weaknesses, and apply lessons learned to strengthen and enhance disaster preparedness on an everyday level. The hierarchy outlined in Figure 29 is essential to the CompStat meeting design. The Police Commissioner rarely attends, and if so to announce new initiatives or hear an overview of the presentation. CompStat is under the direction under the Chief of Department and tasked to the Deputy Commissioner of Operations (DCO). The DCO is on the same level of authority as the Bureau Chiefs which is important as the DCO and Bureau Chiefs are in a physical and authoritative position to question subordinates. The Deputy Mayor of Infrastructure would assume a position similar to the NYPD's Chief of Department and designate a position similar to the NYPD's DCO in the duplicated model for CI, as depicted in Figure 34.

Figure 34. Hierarchy of CompStat Model and the Mayor's Office of Infrastructure Model



This thesis recommends taking infrastructure concerns off the overburdened plate of Mayor's Office of Operations and create a new Deputy Mayor of Infrastructure to collaborate with New York City's Emergency Management. The current New York City Commissioner of Emergency Management is Joseph Esposito, who is a former Chief of Department for the New York City Police Department. In that assignment, he commanded the CompStat process for 13 years (2000–2013). Commissioner Esposito's experience commanding CompStat and NYC EM will be immensely valuable in the transition process. His experience in ensuring communication and accountability in the NYPD would translate well into the new collaboration of NYC EM and the Mayor's Office of Infrastructure, and we would have all hands on deck to improve CI.

The goal of introducing CompStat principles to CI is to enable agencies to adapt to the constant cycle of the CompStat principles, collecting intelligence, tactics/deployment, and, most importantly, follow-up. The duality of the CompStat process is the pre-planning or initiative phase and the follow-up phase. In pre-planning, commanding officers make plans while the follow-up phase focuses on the accountability aspect of critiquing actions and plans whether positive or negative. The culmination of the

CompStat process is the CompStat meeting, but both the leaders at the dais and the presenting units engage in pre-CompStat meetings, resulting in the coordination of efforts. For the dais, the DCOs office and the respective Bureau chiefs meet a day before CompStat to discuss the highlighted issues for CompStat. This meeting ensures CompStat discussion of the most relevant topics, as well as how to limit the session to an acceptable length. The presenters, mostly precinct personnel, will meet during the week leading up to CompStat to discuss the issues observed. On the day before CompStat, those units will be called down to present the observations to the borough chief of the respective borough presenting. This process applies to other units such as detective squads, robbery squads, etc., who anticipate presenting at CompStat.

This pre-CompStat process is carried on by some successful borough chiefs or unit commanding officers regularly with little influence of the CompStat schedule, ensuring that communication and the principles of CompStat are adhered to daily. Under a system of regular pre-CompStat meetings, members are kept apprised of issues and monitor performance typically called into question at a real CompStat. Frequently, issues discussed at pre-CompStats will not make it onto the agenda at the CompStat meeting due to time constraints and level of importance. The pre-CompStat meeting ensures that all issues are being looked at and under the direction of the borough commander.

This model develops a pre-meeting into each agency conducting respective mini-CompStats. Subordinates brief agency heads on issues that may arise at CompStat and the agency head instructs subordinates on issues observed. This system translates into mini-CompStats off the CompStat schedule that create a system of accountability through the year.

C. PRINCIPLES APPLIED TO NYC CI

Chapter V delineated the NYPD's CompStat model and the four principles that define the process; the next section explains how we can apply those to the Mayor's Office of Infrastructure. Adapting those four principles to the recommended Deputy Mayor of Infrastructure provides a methodology to coordinate multi-agency cooperation although organizational behavior will need to adjust.

1. Accurate and Timely Intelligence

Collection of intelligence is an agency-centric design that is already occurring but needs to be analyzed and compared to other agencies. Accurate and timely intelligence is a natural aspect of CompStat model for a citywide multi-agency application. In 2003, New York City Department of Information Technology and Communications (NYC DoITT) created the 311 quality-of-life hotline system. Customers can call to get information or make complaints about hundreds of issues such as garbage collections, alternate side parking, and noise. Originally intended to alleviate traffic to the 911 emergency dispatch system, 311 has become a repository for searchable requests documented and issued a unique identifying number for follow-up. The 311 system averages 10 million calls a year and provides services in 170 languages. Since the creation of the 311 system, NYC DoITT has added a 311 website and apps for iOS-, Android-, and Windows-operated cellular phones. The volume of calls and methods of contact demonstrate the usage rate and the access that citizens have. The complaints are collected and forwarded to respective agencies for action and replies are stored in the 311 system. The intelligence is being collected and used but not compared against information from other agencies.

In preparation for research on this thesis, I attended meetings and seminars on critical infrastructure by several government representatives from New York City Council, New York State Assembly, and the Staten Island Borough President. All presenters had no shortage of stories of governmental failure in improving infrastructure in a prioritized manner. These officials, currently the repository of failures, can also be a source of intelligence to the respective agencies. The incidents depicted Chapter IV all indicate a need for oversight, communication, and accountability.

2. Effective Tactics

Effective tactics in the CI model come in the form of civilian agencies and industry representatives to discuss new technologies and initiatives with city agencies responsible for improvements. In the NYPD's CompStat meetings, outside agencies are

invited to come and observe and participate. Also, NYPD units provide demonstrations on new tactics and equipment.

Effective tactics tie in with rapid deployment. Rating systems are in place and demonstrated in previous sections of this thesis. The American Society of Civil Engineers, the NYC DOT, the Rudin Center, TRIP, Center for an Urban Future all use the same collected rating systems to indicate which roadway or bridge needs repair first. This information and the presence of those groups at CompStat would enforce the prioritization.

3. Rapid Deployment

Rapid deployment coupled with effective tactics relies on taking the intelligence, developing a plan to address it, and getting to it quickly based on priority. PlowNYC is a website to enable citizens to track the progress of snow removal vehicles and to determine the rating of their street in the priority removal order—primary, secondary, and tertiary.²⁴⁵

The pre-event planning aspect of CompStat would enable joint rapid deployment by agency representatives engaging in conversation about processes of their respective organizations. Utility companies in New York City—Con Edison, National Grid, and Verizon—have a plan in place in which they confer on upcoming projects. As a result, the agencies can work together in one area, work more efficiently, reduce traffic congestion, and save money. City agencies do not currently have a similar plan unless the work comes under the Department of Design and Construction Capital Projects.

4. Relentless Follow-up

Relentless follow-up is the tricky part. Developing a system where one person with the authority of the mayor and can question city agencies could cause a hostile environment. The goal is to encourage free conversation between agencies. The planning phase of the meeting should be a moderated discussion between agencies. The follow-up

²⁴⁵ “PlowNYC,” New York City Department of Sanitation, accessed September 7, 2016, <http://maps.nyc.gov/snow/#>.

and accountability phase does not have to be punitive but can be taken with the authority of the Deputy Mayor of Infrastructure. Being witness to hundreds of CompStat presentations, I can testify to the resistance of some. Precinct commanders and borough commanders unwilling to participate in the NYPD's 1994 CompStat retired or adapted. The result was and still is a massive well-documented decrease in crime. The result of this recommendation is a vastly improved system of government-supervised infrastructure.

5. Limitations

Researching the CompStat process, the state of critical infrastructure, and a method of applying CompStat principles to CI uncovered limitations. The origination of CompStat in 1994 was not without setbacks, retirements, and transfers. The government is known to work in its silo-based system with little change from the previous administration, regime, or generation. A conversion of that mindset into the NYPD's team mentality is necessary. Accountability and measurement are keys to successes, recognition, and promotion of those who excel.

6. Summary

The recommendation of this thesis is to incorporate agencies and commissioners along the ESF structure. This grouping would enable commissioners in compatible or related fields to be grouped together for presentation at the NYC Deputy Mayor of Infrastructure's CompStat. The quotes in the Chapter II Section B and in Chapter V of this thesis display that CompStat is not without its downsides. It can be aggressive, confrontational, and sometimes demeaning, and documentation exists of attempts to report false numbers to make the appearance of declining crime. The positive outcomes of reduced crime and increased quality of life greatly outweigh the negative.

The CompStat process is not a panacea. It is not a magical cure-all that will transform a poorly run and inefficient organization into a model of public service excellence. Rather, it is an additional tool that can be used

to enhance performance by means of careful measurement and planning and effective allocation of resources.²⁴⁶

CompStat requires, fosters, and forces buy-in by all involved. It is a system to build a hard-working team around a mission. Applying the CompStat principles to CI would create similar partnership in all agencies involved in particular disciplines.

This thesis details hierarchies of authority in both the NYPD and the city of New York. When the discussion relates to public safety, public infrastructure, and using tax money to ensure both, the real bosses are the citizens of New York City. The ultimate goal of this thesis is to create a fair system of accountability in which citizens can witness the transparency and interact with the system in place. The CompStat system has punished and rewarded members. This recommended system must gain success with limited punishment and much public praise.

Democratic governments are also obligated to be accountable to their owners—the citizenry. Performance management principles and practices give governments the ability to provide easily understood and timely information to the public so citizens can assess the results their government is producing and fulfill their role as collective owners of their governments.²⁴⁷

The goal of accountability is to create a better product for consumers. In applying accountability to CI, the citizens and taxpayers get a better transportation system, a better use of tax money, and a safer of emergency response and evacuation system.

The NYPD did not invent the idea of accountability, but they are one of few city agencies to implement it and receive the documented extreme results. The National Academy of Public Administration is a non-partisan, non-profit organization to “assist government leaders in building more effective, efficient, accountable, and transparent

²⁴⁶ O’Connell, Using *Performance Data for Accountability*, 179–223.

²⁴⁷ National Performance Management Advisory Commission, *A Performance Management Framework for State and Local Government: From Measurement and Reporting to Management and Improving* (Chicago, IL: NPMAC, 2010).

organization.”²⁴⁸ Their 1991 report, *Performance Monitoring and Reporting by Public Organization* strongly recommends agency heads:

- Monitor program quality to improve performance and credibility.
- Implement performance monitoring.
- Obtain agreement between policy making and operating levels.
- Involve citizens in setting goals and monitoring results.
- Collect data on system performance
- Report to elected officials.²⁴⁹

This 25-year-old report predates CompStat by three years and details principles similar to those in CompStat, yet 25 years later that system has yet to be developed for CI.

This chapter has detailed the methodology to be used to promote CI safety via the mayor moving this task from under the overburdened Mayor’s Office of Operations and dedicating a new office to CI. This office, working with NYC EM, promotes communication, collaboration, and accountability to city agencies. The CompStat Unit of the new Mayor’s Office of Infrastructure can duplicate the advances to crime reduction by the NYPD’s CompStat program into NYC CI. Chapter VII stresses the importance of NYC CI for emergency response, evacuation, and routine travel.

²⁴⁸ “Who We Are,” National Academy of Public Administration, accessed September 7, 2016, <http://www.napawash.org/about-us/who-we-are.html>.

²⁴⁹ “Performance Monitoring and Reporting by Public Organizations,” National Academy of Public Administration, November 8, 1991. Washington, DC: NAPA.

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VII. CONCLUSION

Institutions parade goals and mission statements whose benevolent generalities discreetly obscure the conflicts and contradictions of day-to-day activity.

—H. W. Love²⁵⁰

The federal government has critical infrastructure (CI) plans, reviews, and critiques all done by federal agencies; the New York State system has plans, but no reviews or critiques; and finally, the New York City system has no plans, no reviews and only critiques by transportation think-tanks. Concrete government-run critiques of agencies and follow up, currently nonexistent, must become the new model to ensure accountability and communication, ensuring improved CI. As one expert has noted, “Performance assessment and performance indicators are tools to manage with, not a substitute for management. They aid in decision making, not take its place.”²⁵¹

This thesis began by examining federal plans and directives; in continuing research, the author learned that those do not affect local municipalities, however the lack of plans and follow-up in those municipalities *does*. Documentation has shown horrifying information on the current state of critical infrastructure and the disasters that can occur as a result. Second, this thesis provided a thorough background of the CompStat system and its accomplishments and flaws. Third, this thesis developed a model to incorporate the successes of CompStat with the issues of critical infrastructure and combine them into a NYC Mayor’s Office of Infrastructure, following the ESF model of NYC Emergency Management, and begin a CompStat program to promote accountability through follow-up and communication.

²⁵⁰ H. W. Love, “Communication, Accountability and Professional Discourse: The Interaction of Language Values and Ethical Values,” *Journal of Business Ethics* 11, no. 11 (1992): 883–892.

²⁵¹ Stephen P. Osborne et al., “Performance Management and Accountability in Complex Public Programmes,” *Financial Accountability & Management* 11, no. 1 (1995): 19–37.

The topic of this thesis was developed in May 2015, while the author was stuck in traffic on a normal day, in Staten Island, and traffic had become a sea of impassable parking lots. The research began shortly after and continued through fall of 2016. While researching government documents, media sources, think-tank organizations reports, and seminars presented by the Commissioner of NYC Emergency Management and local elected officials, the author was unable to find a NYC office dedicated solely to infrastructure, but did find a theme within the NYC Mayor's Office of Operations. A "theme" does not fix roads and bridges; therefore, we need a separate office to prioritize CI. The lack of documentation displays a need for the mayor's office to move infrastructure review out from the Mayor's Office of Operations. This is not a condemnation of that office, but a recommendation that critical infrastructure be addressed in a more direct manner. The Mayor's Office of Operations collects and posts ratings of city agencies to create transparency in government, but the office is lacking in follow-up, communication, and accountability as recommended by this thesis. Moving the infrastructure theme into its own office reassures the public that the current administration is taking the future of CI seriously. The programs in place can be expanded upon to promote a brighter future for CI.

During this research, I have been called a "pissed-off constituent" and mocked that I should just call my thesis "Why Do We Fill in Potholes Twice." While all of that may be true, this process has informed me of the current state of CI, the unintended future if current systems are not improved, and how a model of accountability that changed the course of the NYPD and crime reduction can yield similar results in CI. This research was done and presented in a manner to establish a more accountable infrastructure partnership. Concerns are based on the current inability to leave New York City on an average day, thus mass evacuation would be impossible. Traffic and construction work cause delays in emergency response to routine police, fire, medical calls, and also to major events.

The large-scale implications and interdependencies of the critical infrastructure system and how those relate to homeland security are important aspects to keep in mind. The incidents discussed are from Staten Island, the smallest borough of New York City

with a population of approximately 400,000 people²⁵² and third largest in terms of square miles.²⁵³ These sample events are the same transportation-related issues that arise in all of New York City due to being overseen by the same agencies. Furthermore, the issues presented demonstrate processes that affect critical infrastructure and homeland security nationwide. While the minutia deals with road repair and bridge repair, the larger scale issue addresses emergency response to events and the concerns regarding evacuation of the city in the event of a terror-related incident or weather disaster similar to 2012's Hurricane Sandy.

Staten Island, New York City, and the United States are dealing with shrinking budgets and increasing repair and replacement costs. Contained in this thesis is documentation from agencies citing significant defects with CI in the U.S. as well as the associated exorbitant prices tags. Staten Island is a microcosm of NYC. The examples cited in this thesis are small scale but indicators of a larger problem in the lack of accountability and communication. Similar to the broken windows theory, we can fix small problems before they become larger.

The NYPD uses the motto "do more with less" when faced with issues of shrinking forces. The way to do more with less is to institute policies that ensure the resources available are performing the correct tasks at the proper location. The CompStat process has contributed to a monumental crime drop, an increase in quality of life, and reclaiming of once war-torn neighborhoods. Executives participating in the original CompStats either participated and increased their responsibility level or faced replacement. CompStat achieved its mission of decreased crime and improved the quality of life by providing increased accountability. The flaws and critiques discussed were a small price to pay for that safety.

The recommendations in this thesis are simple. New York City government must make agencies more interwoven in their responsibilities. The examples relate to some of

²⁵² "Current and Projected Populations," New York City Department of Planning, August 19, 2016, <http://www1.nyc.gov/site/planning/data-maps/nyc-population/current-future-populations.page>.

²⁵³ "Borough (New York City)," Wikipedia, August 19, 2016, [https://en.wikipedia.org/wiki/Borough_\(New_York_City\)](https://en.wikipedia.org/wiki/Borough_(New_York_City)).

the city agencies, therefore the systems proposed should begin with those and expand to all disciplines. Agencies track efforts on an individual, agency-based, silo-driven system. The proposed system for the NYC Deputy Mayor of Infrastructure and the CompStat Unit recommended within accomplishes three missions at once: increase accountability, improve communication, and promote inter-agency collaboration.

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